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RESEARCH PAPER P-232

LEVELS OF NOCTURNAL ILLUMINATION

Lucien M. Biberman
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January 1966

INSTITUTE FOR DEFENSE ANALYSES
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Contract SD-50
Task T-36

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ABSTRACT

Summary tables show, for four lunar months (mid-summer, mid-fall, mid-winter, and mid-spring), the number of hours in which the illumination exceeds levels in 8 decades from 1.5×10^{-6} lumens per square foot to $1.5 \times 10^{+1}$ lumens per square foot; the full tables list the hours, day by day, in which the illumination exceeds the same 8 levels. Note that the sum of the hours not exceeding and the hours exceeding a given level equals a constant which is the total number of hours in a lunar month.

So that these tables may be more easily understood, they also have been plotted at levels of 1.5×10^{-5}, 1.5×10^{-3}, 1.5×10^{-1}, and $1.5 \times 10^{+1}$. These curves show the number of hours per day as a function of date, the time that terrestrial illumination equals or exceeds these values. There are separate sets of tables for latitudes of 0, 30, and 60 degrees.

PREFACE

The calculations reported herein were performed for the Office of Communications and Electronics of ODDR&E at the suggestion of Lucien M. Biberman as an aid to understanding one of the many factors determining man's ability to see at night.

The data are designed to indicate day by day for three latitudes the number of hours when several nominal values of nocturnal illuminance from sunlight and moonlight are exceeded. The nominal values chosen cover eight orders of magnitude.

The tables presented herein are based upon calculations and approximations employing circular orbits. Longitudinal effects are ignored.

CONTENTS

FIGURES

FIGURES (Cont'd)

PART 1: SOME COMMENTS ABOUT UNITS AND NOMENCLATURE

Perhaps no branch of physics gives more difficulty with regards to nomenclature than that portion concerned with radiant energy and power in the region of the electromagnetic spectrum to which the eye responds. This stems from a number of factors, possibly the most import being that Light and related Luminous (or photometric) quantities are not basic physical quantities but are defined directly or indirectly through measures in which the physiological response of the human eye (daylight adapted) is the means of measurement. As a result, we have the definition:

> Light is the aspect of radiant energy of which a human observer is aware through the visual sensations which arise from the stimulation of the retina of the eye....Light thus defined is a psychophysical concept. Light is not identified with either radiant energy or visual sensation. The photographic process, radiometric power and the erythemal potency are examples of other aspects of radiant energy. Light, however, is the aspect of radiant energy of which human observers are aware through the intermediate agency of the eye and the sensation and perceptions resulting from stimulation of the retina.*

Long ago, before precise understandings existed concerning radiant energy and its derivative effects, there was a need for standards of light-related measures. The standard candle was born--and now that physics has better means at its disposal to create standards, and has done so, the older sperm-whale oil definitions have been changed to take advantage of better radiometric standards, but--the human eye is still the relating factor that transforms, both in fact and in concept, radiant power into light.

Thus, we have the problem of a precisely defined unit, the candela, which when measured by an imperfect radiation detector, the eye, gives the "proper" value of Light, but when measured by a perfect (i.e., uniformly responding) instrumental detector, produces too great a response. The perfect detector measures the radiant property while the eye measures the luminous property; the two are related. The response curve of the light-adapted human eye, the relating function, is shown in Fig. 2.

*The Science of Color, Optical Society of America, 1963.

λ (nm)	V (λ)	λ (nm)	V (λ)
385	4 00 -5	585	8 16 -1
390	1 00 -4	590	7 57 -1
395	2 00 -4	595	6 95 -1
400	4 00 -4	600	6 31 -1
405	6 00 -4	605	5 67 -1
410	1 20 -3	610	5 03 -1
415	2 20 -3	615	4 41 -1
420	4 00 -3	620	3 81 -1
425	7 30 -3	625	3 21 -1
430	1 16 -2	630	2 65 -1
435	1 68 -2	635	2 17 -1
440	2 30 -2	640	1 75 -1
445	3 00 -2	645	1 38 -1
450	3 80 -2	650	1 07 -1
455	4 80 -2	655	8 20 -2
460	6 00 -2	660	6 10 -2
465	7 40 -2	665	4 50 -2
470	9 10 -2	670	3 20 -2
475	1 13 -1	675	2 30 -2
480	1 39 -1	680	1 70 -2
485	1 69 -1	685	1 19 -2
490	2 08 -1	690	8 20 -3
495	2 59 -1	695	5 70 -3
500	3 23 -1	700	4 10 -3
505	4 07 -1	705	2 90 -3
510	5 03 -1	710	2 10 -3
515	6 08 -1	715	1 48 -3
520	7 10 -1	720	1 05 -3
525	7 93 -1	725	7 40 -4
530	8 62 -1	730	5 20 -4
535	9 15 -1	735	3 60 -4
540	9 54 -1	740	2 50 -4
545	9 80 -1	745	1 70 -4
550	9 95 -1	750	1 20 -4
555	1 00	755	8 00 -5
560	9 95 -1	760	6 00 -5
565	9 79 -1	765	4 00 -5
570	9 52 -1	770	3 00 -5
575	9 15 -1	775	2 10 -5
580	8 70 -1	780	1 50 -5

Zahlendarstellung: 4 00 −5 bedeutet $4{,}00 \cdot 10^{-5}$

FIGURE 1 The Photophic Response of the Eye

(Prof. Dr. Dietrich Hahn, Dr. Joachim Metzdorf, Dr. Ulrich Schley, and Dipl. Phys. Joachim Verch, Seven-Place Tables of the Planck Function for the Visible Spectrum, Academic Press, New York, 1964.)

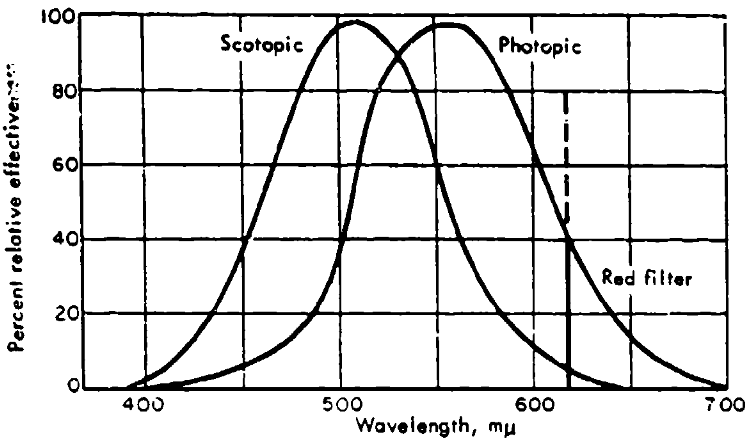

FIGURE 2 Luminosity Curves for Scotopic (rod) and Photopic (cone) Vision. Since the Maxima are Arbitrarily Set at 100, these Curves Give no Information About the Relative Sensitivity of the Rods and Cones (Hecht and Yun Hsia, 1945)

One other problem looms. The science of photometry is the comparison of light-related quantities. The problems of photometry are straightforward whenever one deals with a comparison of nearly monochromatic light. But when the colors of light are different--the measurement of an intensive property of things that are qualitatively different gives rise to the queasiness often experienced when comparing apples and oranges. How does one compare the brightness of a yellow lamp with that of a blue lamp?

Fortunately, the sensation of light may be stated to be proportional to the integral of the radiometric power incident upon the retina multiplied by a retinal response function. This function weighs each wavelength to which the retina responds by an amount to which the retina would respond if exposed to radiation in which radiometric power were equal at all wavelengths.

From all this one comes to a definition of Luminosity, K, which is the ratio of any photometric quantity to its radiometric counterparts, i.e., the luminous efficiency of radiant energy. "Calculated in terms of luminous and radiant flux, for instance, luminosity

$$K = K_m \frac{\int_0^\infty \bar{y}_\lambda P_\lambda d\lambda}{\int_0^\infty P_\lambda d\lambda}$$

The ratio of the integrals is the luminosity of P_λ relative to the maximum possible luminosity K_m of radiant energy. This ratio may therefore be called the relative luminosity of P_λ and may be denoted by $\bar{y}$, so that $K = K_m\bar{y}$. Although K is customarily specified in terms of lumens per watt, any radiometric quantity may be multiplied by this factor to obtain the corresponding photometric quantity, be it luminous flux, luminous energy, luminous density, luminous intensity, luminous emittance, luminance, or illuminance."*

To add to all the above, we have English units very commonly used and which in this paper we shall use. These values of illuminance or illumination--terms that are used interchangeably, although illuminance is preferred--are expressed in "foot-candles," which are lumens per square foot. In our paper, both the terms "foot-candles" and "lumens per square foot" will be used interchangeably.

Lastly, we have the terminology of the astrophysicist who goes his own way with still a further set of concepts for radiometric terminology--we shall not consider the stellar magnitudes, but we must consider surface brightness as radiance, which when modified by eye response is luminance. The astrophysicists use units of ergs/cm^2 steradian second or photons/cm^2 steradian second for surface brightness (radiance).

Chamberlain, Hunter, and Roach define the unit Rayleigh as follows: If I is surface brightness in units of 10^6 photons/cm^2 steradian second, the $4\pi I$ is a rayleigh.

The use of these units and their related systems of units, like multiple foreign tongues, can be mastered only through frequent use.

*John, W.T., The Science of Daylight, Optical Society of America, 1963.

PHYSICAL			PSYCHOPHYSICAL		
Radiator (source of radiant energy) Radiation (process)			Luminator (source of luminous energy) Lumination (process)		
Radiometry	Symbol	m.k.s. units	Photometry	Symbol	m.k.s. units
Radiant energy	U	joule	Luminous energy	Q	talbot
Radiant density	u	joule/m^3	Luminous density	q	talbot/m^3
Radiant flux	P	watt	Luminous flux	F	lumen
Radiant emittance	W	watt/m^2	Luminous emittance	L	lumen/m^2
Radiant intensity	J	watt/ω	Luminous intensity	I	lumen/ω(candle)
Radiance	N	watt/ω x m^2	Luminance	B	lumen/ω x m^2†
Irradiance	H	watt/m^2	Illuminance	E	lumen/m^2 (lux)
Spectral reflectance	ρ		Luminous reflectance	r	
Spectral transmittance	τ		Luminous transmittance	t	
Ratio of photometric quantity to corresponding radiometric quantity (standard units) = luminosity, K (luminous efficiency, lumens/watt) of radiant energy involved.					

*The nomenclature given in this table and used in this report differs in some details from the nomenclature recommended by the Illuminating Engineering Society and adopted by the American Standards Association. These modifications of the standard nomenclature are proposed as somewhat simpler and more systematic, with the hope that they may be considered in a future revision of the standard nomenclature. The symbols shown in this table are identified with those adopted by the American Standards Association. The symbol ω used in Fig. 3 denotes a unit solid angle, the solid angle subtended by one square meter of surface of a sphere having a radius of one meter.

†Candle/m^2.

FIGURE 3 Correspondence of Radiometric and Photometric Nomenclature*

PART 2. INTRODUCTION

One of the many factors determining a man's ability to see at night is the amount of light on the scene or illuminance. Astrophysical and geophysical phenomena provide the sources of illumination (illuminance) on the one hand and attenuation on the other. Examples of the more significant natural sources of light are the moon and night glow (known as airglow); examples of sources which are not significant and inappreciably affect night vision are light from the Gegenschein (see Fig. 4) and the planets.

Phenomenon	Luminance, candles/ft^2
Milky way, dimmest region, near Perseus	1×10^{-5}
Gegenschein	1.5×10^{-5}
Visible night glow (zenith)	2×10^{-5}
Milky way, brightest region, near Carina	4×10^{-5}
Zodiacal light (30 deg elongation)	1.1×10^{-4}
Visible night glow (edge-on)	6×10^{-4}
Great Orion nebula M42	5.6×10^{-3}
Full moon	$4 \times 10^{+2}$
Fluorescent lamp, 4500 white	$4 \times 10^{+2}$

FIGURE 4 The Luminance of a Variety of Celestial Objects. The Fluorescent Lamp is Shown for Comparison (from Dunkelman and Hennes, 1965)

First let us discuss radiation sources and the irradiation upon scenes without reference to their effect upon the eye. We shall use radiometric units and terminology.

It is practicable in discussing passive light sources to divide sources of night irradiance into the variable and the relatively steady components. The relatively steady component is made up of the night-airglow, or nightglow, the Zodiacal light, and integrated starlight, all of which are frequently lumped together and called light-of-the-night-sky. While we speak of this as being the relatively stable component of night irradiance, it is known from many observations that the nightglow, for example, varies frequently as much as a factor of two and even more (up to a factor of five) from season to season, and it also has latitude effects. However, compared to the variable component of the irradiance available at night due to the moon, the light of the night sky indeed is quite stable.

The variable component is, of course, the irradiance produced by the sun and the moon. The lunar irradiance is a strong function of the phase of the moon and the angle of elevation of the moon. In the case of lunar elevation, however, the change of irradiance is very significant from moonrise to the time when the moon is up, say, 10-deg or so, and then from 10-deg lunar elevation to moonset. During the period between the 10-deg elevation points, the irradiance varies very little with lunar elevation. On the other hand, lunar phase (relative to the sun) is extremely important (see pp. A-12 and A-16).

The quality of moonlight is essentially that of sunlight (Dunkelman and Scolnik, 1959; Malitson, 1965), but reduced considerably in irradiance (due to low lunar albedo) and modified spectrally according to Fig. 8.

For problems more directly concerned with vision we now turn our attention to eye related quantities and will use luminous (photometric) quantities and terminology.

Solar illuminance for various solar angles of elevation and lunar illuminance for several phases are shown in the appendix, taken from the extensive work of Brown (1952). Due to the difficulty in obtaining copies of Brown's work, it has been reprinted as an Appendix.

For one interested in pursuing independent calculations, it should be apparent that the spectral distribution of solar irradiance outside the atmosphere is well known (see curve M = 0, Fig. 5). This curve, however, is not the one that applies to solar spectral irradiance at sea level. The strong spectrally dependent processes of absorption and scatter modify the incident radiation from the sun according to the path length traversed. The curves labeled M = 1 through M = 5, show the net results of the action of a "clear atmosphere" for path lengths equivalent to air masses of 1 through 5.

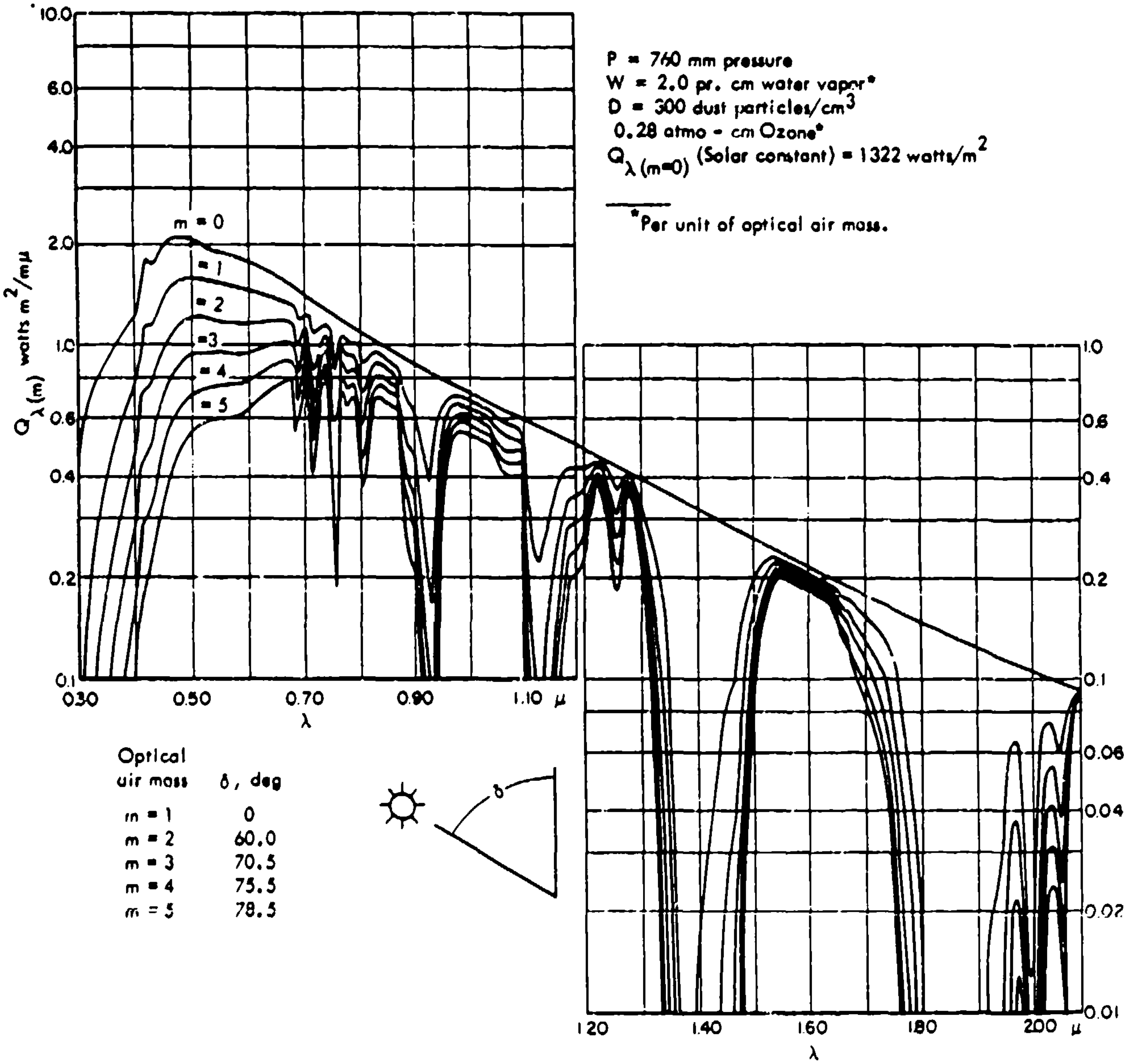

FIGURE 5 Solar Spectral Irradiance Curves at Sea Level with Varying Optical Air Masses (From Handbook of Geophysics, USAF Air Research and Development Command, New York, 1961 (Revised edition)

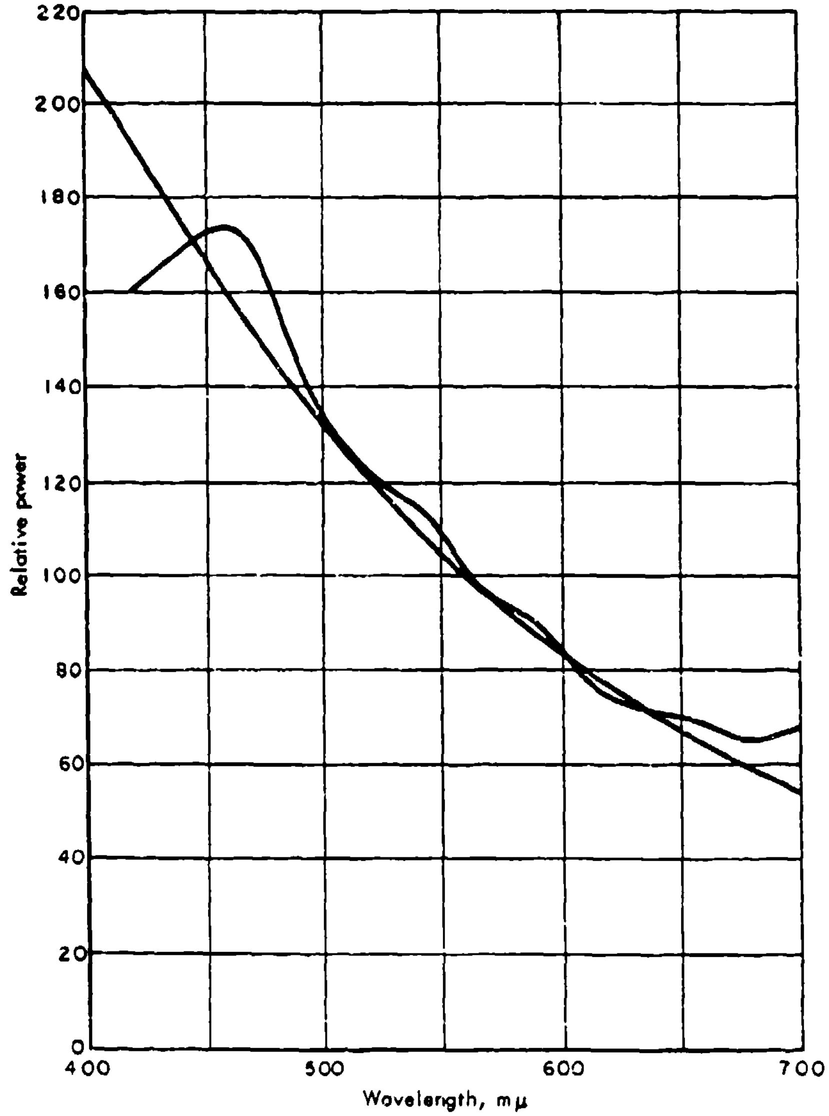

FIGURE 6 The Spectral Distribution of Light from a Clear Sky; Also Shown is the Curve for a Blackbody at 11,500°K. (From J.W.T. Walsh, The Science of Daylight, London, 1961)

The colour of the clear blue sky is by no means uniform. Opposite the sun the sky is bluer than it is in the sun's vicinity. The colour temperature on an exceptionally clear day may reach 60,000°K (16.7 mireds) but on average for the zenith sky at Cleveland on a large number of ordinarily clear days was found to be 13,700°K (73 mireds).

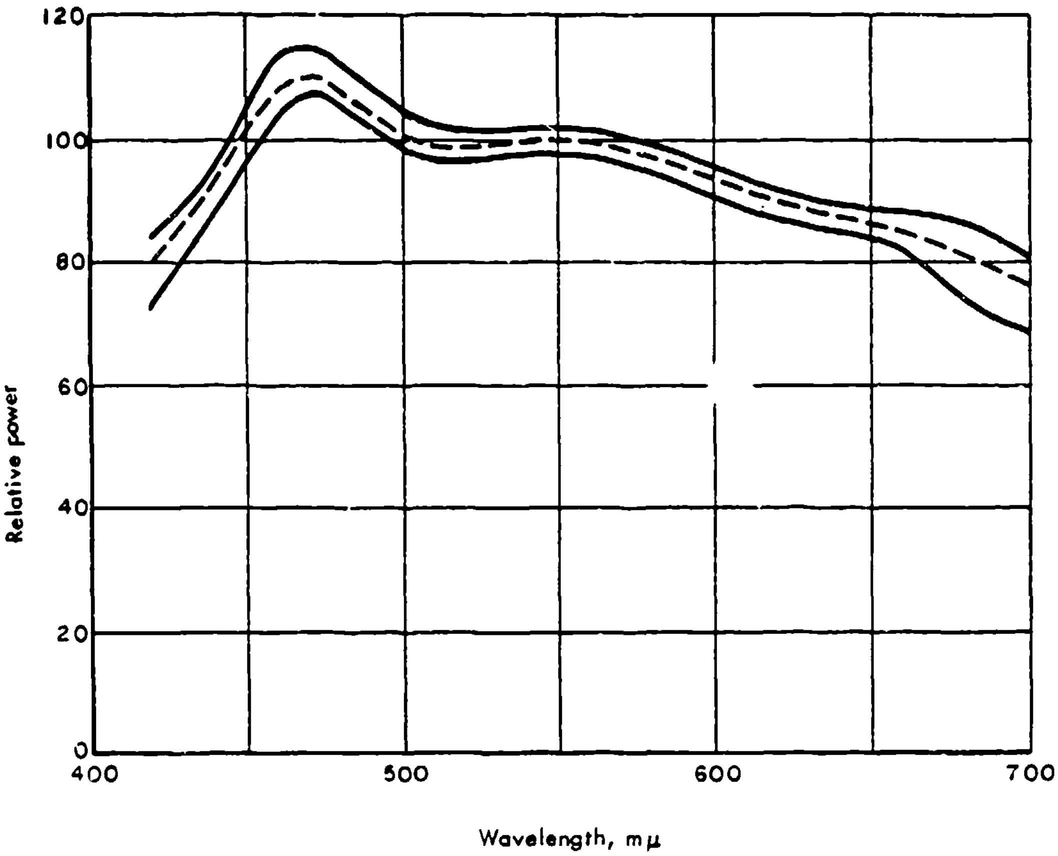

FIGURE 7 The Spectral Distribution of Light from Sun and Clear Sky
(From J.W.T. Walsh, The Science of Daylight, London, 1961)

The radiance and color of the sky also appear to be as they are--instead of a black star-studded dome--because of these same processes. This is illustrated in Fig. 6 and 7.

At night the solar radiation reaching the earth has traveled through a long path refracted possibly ten to fifteen degrees from below the horizon and multiply scattered. Thus, the spectral content of the sunlight incident upon earth at night is strongly modified from that incident upon earth at the outer fringes of the atmosphere.

Moonlight is sunlight reflected from the surface of the moon. It is subject to all the effects discussed above for sunlight, but in addition is also modified by the selectivity reflective characteristics of the lunar surface (see Fig. 8) and the attenuation of the inverse square of the path.

For detailed, precise calculation, all this must be considered. The consideration of these factors resulted in a discrepancy (somewhat less than a factor of two) between the relative value assigned to moonlight in this report (2.3×10^{-6} of solar illuminance for the equivalent solar angle) and the 3.0×10^{-6} used in the data of Brown. We have adjusted Brown's data accordingly in our calculations, but have <u>not</u> modified his material reproduced in the Appendix.

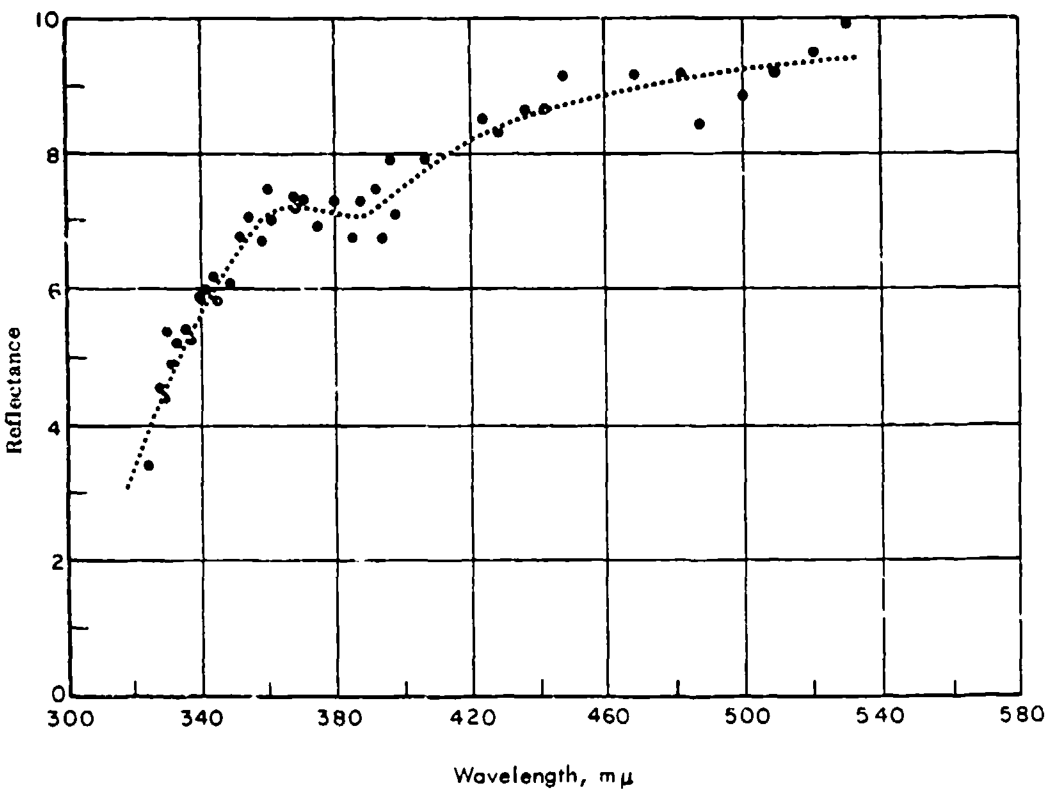

FIGURE 8 Relative Spectral Reflectivity of the Moon

PART 3: NATURAL ILLUMINANCE LEVELS

In nature, the range of illumination extends from 10,000 foot-candles, occurring at high noon in clear sunlight (the sun produces an illuminance of approximately 12,500 foot-candles above the earth's atmosphere), down to 10^{-2} foot-candles at full moon, 10^{-4} for clear moonless night sky and finally 10^{-5} for overcast night sky.

To have a feeling for what these illuminance levels are, it seems proper to give a few examples of how well one can see and photograph at the illuminance levels. A young, trained observer can begin to be able to discern large high-contrast objects at an illuminance level of 10^{-5} foot-candles. If the illuminance is increased by three orders of magnitude to 10^{-2} foot-candles, which is the level of full moonlight, seeing is much improved and it may be possible to make out large newsprint. At the 10^{-2} foot-candles, it is barely possible to discern color; a little more than an increase of one order of magnitude is required before color can be readily distinguished. At this level of more than 10^{-1} foot-candles, visual acuity becomes quite good and is very high at 10 foot-candles (the level of good home and office lighting).

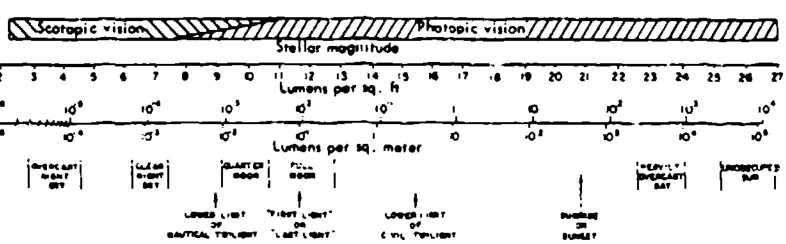

FIGURE 9 Range of Natural Illuminance Levels

PART 4: THE CONSTANT COMPONENT OF NOCTURNAL ILLUMINANCE

The sources of passive light at night, as pointed out earlier, have been divided into two major components, one being highly variable and the other relatively stable. The former is moonlight, whose contribution we have seen varies from zero (new moon) to more than two orders of magnitude (full moon) greater than all other components (neglecting solar twilight). The relatively stable component, the light-of-the-night-sky, is discussed in this section of the report.

The light-of-the-night-sky, recently reviewed by Roach (1963), Krassovsky and Sefov (1965), and others, consists of three major sources: astronomical, interplanetary, and geophysical. In picking out the relevant information and numbers, the units used by each author will be given in the text but in the charts and tables of summary these are converted as necessary and only the more commonly used units will be given. For example, Roach, in discussing the approximate visual radiation at various locations in the universe, uses as a unit of luminance, S_{10}(vis), the "number of 10th magnitude (visual) stars per square degree" as shown in Fig. 10 (from Roach, 1963).

In the work here we are concerned mainly with the column on the extreme right. Of the 451 S_{10}(vis) units, 301 are of astronomical and interplanetary; 150 S_{10}(vis) units or one-third of the visible light-of-the-night-sky is of geophysical (air-flow) origin. On a moonless night, then, these sources of light provide the flux by which to see.

However, as is well known, these sources and the airglow irradiate the earth throughout the visible region and well into the infrared, as is shown below with an irradiance level several orders of magnitude higher than in the visible.

The nightglow (treated in the authoritative book by Chamberlain (1961), and others*) includes strong emissions, both atomic and molecular through the visible and well into the infrared as shown in Figs. 11 and 12. For references, Figs. 13 and 14, reproduced from Roach, show the strong OH spectral radiance distribution

*Roach (1964), Krassovsky, Shefov (1965), O'Keefe et al (1963), Roach (1963), Gush and Jones (1955), Krassovsky, Shefov and Yarin (1962), Hunter, Roach and Chamberlain (1956).

FIGURE 10 Approximate Luminance of Visual Radiation at Various Locations in the Universe in S_{10} (vis) Units

COMPONENT	OBSERVER			
	In Intergalactic Space	In Interstellar Space	In Interplanetary Space	On the Earth
Integrated Nebular Light	1	1	1	1
Integrated Starlight	-	100	100	100
Zodiacal Light	-	-	200	200
Night Airglow	-	-	-	150
TOTAL	1	101	301	451

Source	Wavelength	Absolute zenith intensity: Rayleighs	Absolute zenith intensity: Ergs.cm⁻²(column).sec⁻¹
OH	0.38 to 4.5	5000000	3.6
O_2 (0, 1 atm)	8645 Å	500	$1.1 \times 10^{-[illegible]}$
HI (Hα)	6563 Å	1[illegible]	$4.5 \times 10^{-[illegible]}$
OI	6300, 6364 Å	20[illegible]	6.2×10^{-4}
NaI	5890, 5896 Å	30 (summer) to 200 (winter)	1.0×10^{-4} to 6.8×10^{-4}
OI	5577 Å	250	8.9×10^{-4}
HI (Hβ)	4861 Å	3	$1.2 \times 10^{-[illegible]}$
O_2 (Herzberg Bands)	3000 to 4000 Å	1500	$8.8 \times 10^{-[illegible]}$
N_2^+	3914 Å	(40) †	$2.0 \times 10^{-[illegible]}$
Continuum (Nightglow)	4000–7000 Å	900 (0.3 R/Å Mean)	$5.0 \times 10^{-[illegible]}$
Continuum (Astronomical)		4000 (1.3 R/Å Mean)	$1.5 \times 10^{-[illegible]}$

FIGURE 11 Nightglow Emissions (largely from Krassovsky, Shefov and Yarin, 1962)

	λ	R_λ	I_λ
	Night Sky		
OI	5577	400	$1{\cdot}4 \times 10^{[illegible]}$
OI	6300, 6364	300	$9{\cdot}4 \times 10^{[illegible]}$
NaI	5893 summer	30	$1{\cdot}0 \times 10^{[illegible]}$
	winter	200	$6{\cdot}8 \times 10^{[illegible]}$
H_α	6562	15	$4{\cdot}5 \times 10^{[illegible]}$
H_β?	4861	3	$1{\cdot}2 \times 10^{[illegible]}$
O_2	8645 (0-1) atm	500	$1{\cdot}1 \times 10^{[illegible]}$
O_2	Herzberg bands	1500	$8{\cdot}8 \times 10^{[illegible]}$
OH	Total for all bands	5000000	3.6
Continuum	4000–7000 by 1 Å	2	$6{\cdot}9 \times 10^{-[illegible]}$
	Total for whole range	6000	$2{\cdot}1 \times 10^{[illegible]}$
	Twilight Sky		
OI	6300, 6364	1000	$3{\cdot}1 \times 10^{[illegible]}$
NaI	5893 summer	1000	$3{\cdot}4 \times 10^{[illegible]}$
	winter	5000	$1{\cdot}8 \times 10^{[illegible]}$
LiI	6708	30	$4{\cdot}0 \times 10^{[illegible]}$
HeI	10830	1000	$1{\cdot}9 \times 10^{[illegible]}$
OI	8446	13	$3{\cdot}0 \times 10^{[illegible]}$

The absolute emission intensities are given in Rayleighs (R_λ) and in erg/cm²/sec (I_λ). $I_\lambda = 1.98 \times 10^{[illegible]} R_\lambda/\lambda$, $R_\lambda = 50.5 \times \lambda \times I_\lambda$, where λ is the wavelength in Å. The average seasonal values of the λ 5577 Å, λ 6300 Å and λ 6364 Å emissions of atomic oxygen [OI] and the λ 5893 Å emission of sodium [NaI] are given. The intensity of the emission identified with H_β λ 4861 Å was determined from Yarin's observations in Yakutsk.

The total radiation intensity of all the OH bands is obtained from the data in the table on p. 18. Since the continuum varies greatly the average spectrum intensity in the λλ 4000–7000 Å range is given. The λ 8446 Å emission intensity of OI is measured from observations in summer twilight in quiet magnetic conditions.

FIGURE 12 Average Emission Intensities of the Night and the Twilight Sky (From Krassovsky, Shefov, and Yarin, 1962)

Wave-length air (A)	Tran-sition (v' - v'')	Absolute intensity* in rayleighs (Chamberlain and Smith, 1959)	Wave-length air (A)	Tran-sition (v' - v'')	Absolute intensity* in rayleighs (Chamber Smit
3816.6	9–0	0.023	10828	5–2	1
4172.9	8–0	0.12	11433	6–3	
4418.8	9–1	0.73	12115	7–4	1
4640.6	7–0	0.71	12898	8–5	16
4903.5	8–1	3.8	13817	9–6	1300
5201.4	9–2	11.0	14336	2–0	46000
5273.3	6–0	4.4	15047	3–1	74000
5562.2	7–1	22	15824	4–2	88000
5886.3	8–2	57	16682	5–3	90000
6168.6	5–0	33	17642	6–4	82000
6256.0	9–3	110	16734	7–5	71000
6496.5	6–1	130	19997	8–6	54000
6861.7	7–2	310	21496	9–7	37000
7274.5	8–3	520	28007	1–0	920000
7521.5	4–0	280	29369	2–1	820000
7748.3	9–4	710	30854	3–2	640000
7911.0	5–1	930	32483	4–3	490000
8341.7	6–2	1800	34294	5–4	360000
8824.1	7–3	2800	36334	6–5	260000
9373.0	8–4	3400	38674	7–6	180000
9788.0	3–0	3100	41409	8–7	110000
10010	9–5	3600	44702	9–8	65000
10273	4–1	7600			

FIGURE 13 List of OH Bands in Order of Wavelength

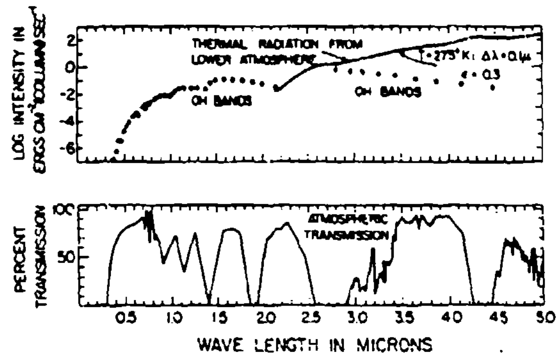

FIGURE 14 Above: Distribution of Intensities* and Wavelengths of the Rotation-Vibration Bands of OH in the Nightglow; Observed to about 1.5 μ and Predicted for Wavelengths Longer than 1.5 μ. Also, the Absolute Intensity of the Thermal Radiation from the Lower Atmosphere for a Temperature of 275°K, a Slit Width of 0.1 μ, and an Emissivity of 0.3

Below: The Transmission of the Lower Atmosphere vs. Wavelength

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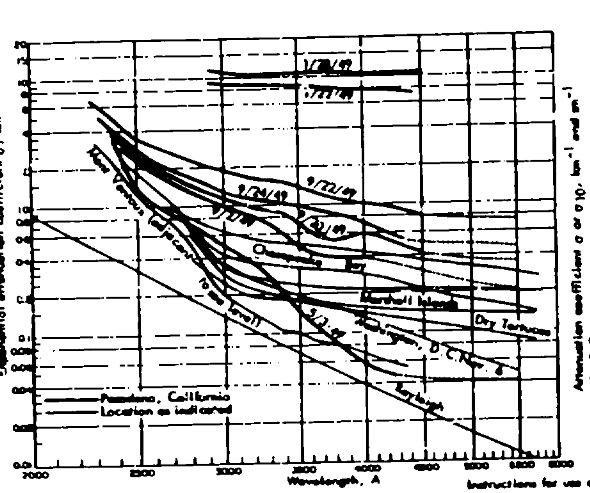
* Most present day terminology applies the term "intensity" as in radiant intensity to point sources too small to be resolved. The terminology in this table is a quote from the original source.

from the visible to 4.5μ. The lower section of Fig. 14 shows the well-known spectral transmittance curve of the lower atmosphere.

Another source of radiation in the night sky is the phenomena of the aurorae, common in the high latitudes and rare in the low latitudes. As interesting as the aurorae are, from the geophysical and display points of view, this source of light must be disregarded as too variable as far as night vision is concerned. At best, one can consider the additional and highly variable flux as a bonus for the high latitude regions.

PART 5: ATMOSPHERIC TRANSMISSION

In the tables presented herein, the data on the incident flux from solar, lunar, and other light sources have taken into account the transmittance losses between the source and the earth's surface. In problems relating to night vision, the path lengths between target and observer are relatively small. Figure 15 (taken from Dunkelman, 1952) illustrates that in the visible region, atmospheric transmission per se is not a major factor except, of course, where fog would probably make the general level of natural night illuminance too low to be useful.



Instructions for use of conversion diagram

Plate B
Typical curves of horizontal atmospheric attenuation of ultraviolet and visible light at Pasadena, California; Chesapeake Bay, Maryland; Dry Tortugas, Florida; Marshall Islands, Pacific Ocean; and Washington, D.C. Included for comparison are curves for theoretically pure air (Rayleigh scattering) and for exceptionally clean air obtained by A. Vassy at Mont Ventoux, Pyrennes

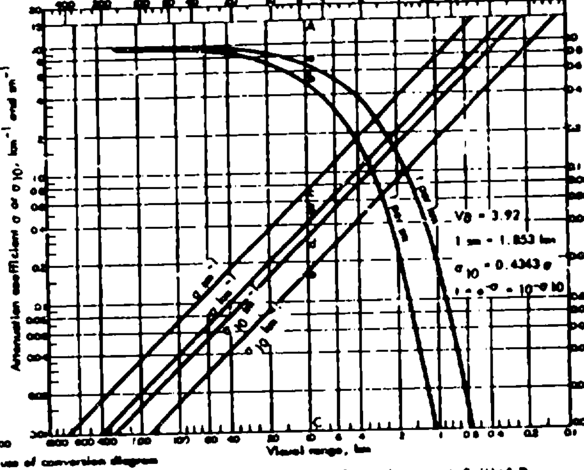


Plate A
Diagram of conversion between attenuation coefficients, σ (base e) and σ_{10} (base 10), and transmittance, t. The length dimensions are in kilometers and sea miles.

From NRL Report #4031, Sept. 10, 1952.

FIGURE 15

PART 6: CALCULATIONS OF THE ILLUMINANCE FROM THE SUN AND THE MOON

The illumination reported herein is computed as the sum of the sun's and moon's illumination, disregarding all other sources of light.

The procedure adopted basically is that of establishing the relative positions of the earth, sun, and moon at 15 minute intervals over a one year period. See Part 8 "Computations for the Moon's and Sun's Positions in the Sky."

Knowing the position of the sun and the moon, the illuminance due to the sun and moon and their phase angles as a function of time is plotted. From a knowledge of this geometry, one can use the tables and curves of Dayton Brown (see Appendix) to construct a second set of curves to represent the illuminance from the sun and moon separately. The values for the full moon are scaled down from solar values by 2.3×10^{-6} and are multiplied by the dependence of the brightness of the partial moon on its phase angle from the light curve (see Appendix). The next step is the summation of these two sources to yield the illuminance from the sun and moon, assuming no cloud cover (Fig. 16).

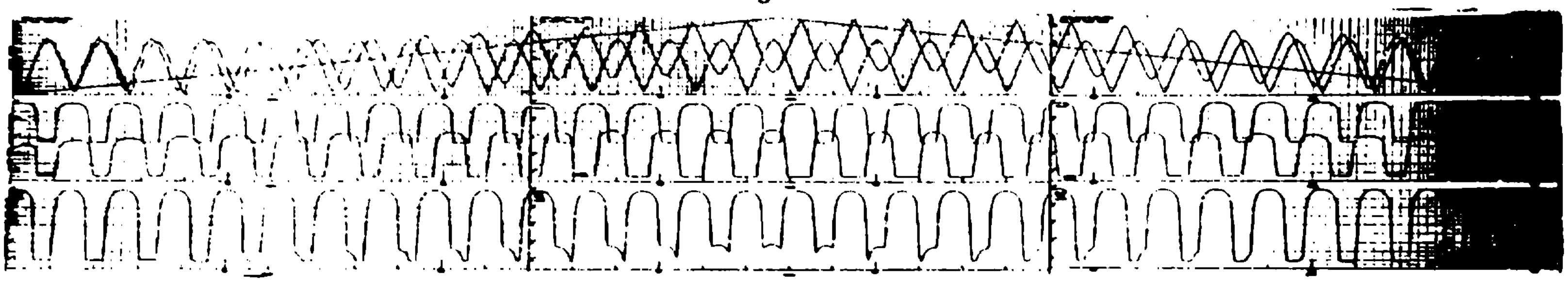
The computations of illumination start at the moment of the eclipse of May 20, 1966, at 7:50 a.m., Greenwich time and Greenwich longitude. Computations were performed for three different latitudes--0°, 30°, and 60°--and at eight different levels--1.5×10^{-6} to $1.5 \times 10^{+1}$--in lumens per square foot to cover the interesting ranges of illumination.

The time for which the illumination is greater than a given level was then summed up over a 24-hour period and presented in hours/day and percentage of a 24-hour period. When the illuminance passes through the given light level, the fraction of the time for which the illumination is greater than or equal to the given level is found by linearly interpolating for the illumination in the computed 15-minute interval.

Refraction, due to the earth's atmosphere, is neglected in the position calculations and therefore the zenith distance used in the illumination calculation is the true rather than the apparent value. A position error of as much as 26 arc minutes occurs when the sun and moon are near the horizon.

The results of these calculations are shown in both plots and tables. The upper set of curves in the following figure illustrates the zenith angles of the sun and the moon for one lunar month. The second pair of curves indicates the

30-deg latitude



May 20, 1966

FIGURE 16 Illuminance from the Sun and Moon
(No cloud cover)

solar and the lunar contributions to surface illumination while the lower curve represents the solar plus lunar illumination as a function of time. It is quite apparent that the sun and the moon and the contributions therefrom to terrestrial illumination follow a cyclic pattern. The frequency of this pattern is different for the sun and the moon so that the solar and lunar contributions to terrestrial illumination go into and out of phase. This results in some rather striking effects concerned with the number of hours of terrestrial illumination that may be expected at various levels of illumination. This may be noted, for example, in the data for a full moon. In cases, however, where the phase angle between the sun and the moon is small, such as the beginning of that lunar month (i.e., May 20), one can see a very gradual decrease in the number of hours at a level as a function of increasing level. Here there is perhaps a shift in the third or fourth place in the period of time concerned as a function of level, while in the case of the full moon (i.e., mid-lunar month), the curves tend to be rather precipitious.

PART 7: THE TABLES

The following tables are based upon the calculation of illuminance from solar and lunar origins computed at 15 minute intervals. These intervals are sorted into groups lying above 1.5×10^{-6} foot-candles at sea level, 1.5×10^{-5}, etc., to $1.5 \times 10^{+1}$. The times in these groups are summed and printed into tables as the number of hours that illumination exceeds the eight chosen levels, for each day of one year beginning with the eclipse of 20 May 1966.

The tables are again summed to give the "Summary Tables," presented first--the number of hours in which the illuminance exceeds the given levels for each of four lunar months. The supplementary tables, "The number of hours that the illuminance does not exceed the level," are given for the same four months.

The tables shown list four significant figures in order that valid trends may be noted. In actual use, two significant figures are appropriate.

The calculations are based upon a normally clear but real atmosphere. For the estimation of more realistic conditions, cloudy skies may be considered to reduce the level of moonlight by $\sqrt{10}$, heavy overcast by 10.

To repeat: The values listed in the tables may be considered supplementary to the more or less steady state value of airglow, which is approximately 10^{-4} foot candles.

For most cases, airglow contributions are trivial compared to either sunlight or moon-reflected sunlight (moonlight). Airglow becomes of interest only when moonlight or sunlight contributions drop to about 10^{-4} lumens per square foot.

For ease of envisioning the results, the tabular data is also presented as a series of graphs. In these graphs, and there is one set for each of the three latitudes, we plot the number of hours per day at each of four levels $1.5 \times 10^{+1}$, 1.5×10^{-1}, 1.5×10^{-3}, 1.5×10^{-5} foot-candles for each day of the year beginning with 20 May 1966. Since the lowest light level will be equaled or exceeded most frequently the curves appear with that expected order: i.e., 1.5×10^{-5} is the uppermost curve and $1.5 \times 10^{+1}$ is the lowest curve, (Fig. 17).

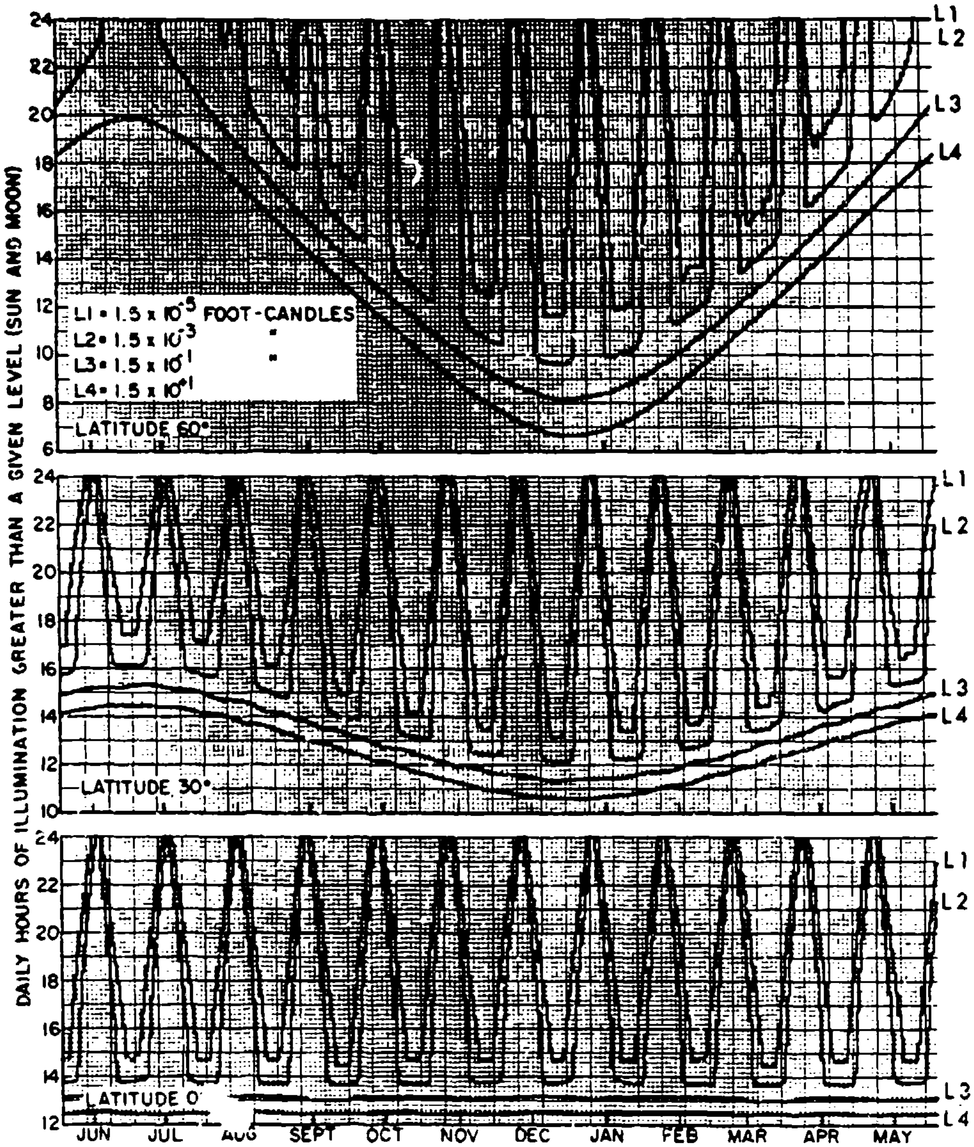


FIGURE 8 Light Levels for Each Day of the Year Beginning May 20th

SUMMARY TABLE A

Number of hours per month in which illumination at earth's surface on a clear day exceeds a given level for each of three latitudes.

Latitude 0

	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
JUN	565.21	81.21	558.39	80.23	539.49	77.51	498.41	71.61
SEP	564.83	81.15	558.37	80.23	540.48	77.66	500.80	71.95
DEC	569.02	81.76	562.63	80.84	543.23	78.05	503.75	72.38
MAR	564.99	81.18	558.55	80.25	541.51	77.80	501.90	72.11
	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN	404.76	58.16	380.90	54.73	372.91	53.58	361.93	52.00
SEP	407.40	58.54	379.16	54.48	371.35	53.35	361.57	51.95
DEC	403.51	57.98	380.84	54.72	372.98	53.59	361.90	52.00
MAR	407.82	58.59	378.89	54.44	371.58	53.39	361.47	51.94

Latitude 30

	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
JUN	602.72	86.60	595.96	85.63	575.56	82.69	531.60	76.38
SEP	572.24	82.22	565.15	81.20	545.14	78.32	501.11	72.00
DEC	547.21	78.62	539.88	77.57	519.20	74.60	473.51	68.03
MAR	569.67	81.85	563.11	80.91	544.54	78.24	501.16	72.01
	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN	453.96	65.22	442.93	63.64	431.89	62.05	419.33	60.25
SEP	403.09	57.92	381.39	54.80	372.51	53.52	361.44	51.93
DEC	364.0[illegible]	52.31	330.94	47.55	320.24	45.98	308.45	44.32
MAR	405.7[illegible]	58.29	383.55	55.11	373.84	53.71	362.96	52.14

Latitude 60

	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
JUN	696.0[illegible]	100.00	696.00	100.00	696.00	100.00	696.00	100.00
SEP	608.77	87.47	601.31	86.39	576.02	82.76	514.76	73.95
DEC	525.35	75.48	515.93	74.13	487.22	70.00	417.62	60.00
MAR	601.79	86.46	595.60	85.57	571.02	82.04	516.50	74.22
	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN	696.00	100.00	690.68	99.24	614.55	88.30	572.01	82.19
SEP	418.32	60.06	400.67	57.57	384.65	55.27	366.27	52.62
DEC	272.95	39.21	239.59	34.47	220.02	31.61	195.62	28.11
MAR	423.42	60.84	405.78	58.30	389.72	55.99	371.19	53.33

SUMMARY TABLE B

Number of hours per month in which illumination at earth's surface on a clear day <u>does not exceed</u> a given level for each of three latitudes.

Latitude 0

	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
	LESS THAN 1.5x10EXP-6		LESS THAN 1.5x10EXP-5		LESS THAN 1.5x10EXP-4		LESS THAN 1.5x10EXP-3	
JUN	130.79	18.79	137.61	19.77	156.51	22.49	197.59	28.39
SEP	131.17	18.85	137.63	19.77	155.52	22.34	195.22	28.05
DEC	126.98	18.24	133.37	19.16	152.77	21.95	192.25	27.62
MAR	131.01	18.82	137.45	19.75	154.49	22.20	194.10	27.89
	LESS THAN 1.5x10EXP-2		LESS THAN 1.5x10EXP-1		LESS THAN 1.5x10EXP+0		LESS THAN 1.5x10EXP+1	
JUN	291.24	41.84	315.10	45.27	323.09	46.42	334.07	48.00
SEP	288.60	41.46	316.84	45.52	324.65	46.65	334.43	48.05
DEC	292.49	42.02	315.16	45.28	323.02	46.41	334.10	48.00
MAR	288.18	41.41	317.11	45.56	324.42	46.64	334.53	48.06

Latitude 30

	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
	LESS THAN 1.5x10EXP-6		LESS THAN 1.5x10EXP-5		LESS THAN 1.5x10EXP-4		LESS THAN 1.5x10EXP-3	
JUN	93.28	13.40	100.04	14.37	120.44	17.31	164.40	23.62
SEP	123.76	17.78	130.85	18.80	150.86	21.68	194.89	28.00
DEC	148.79	21.38	156.12	22.43	176.80	25.40	222.49	31.97
MAR	126.33	18.15	132.89	19.09	151.46	21.76	194.84	27.99
	LESS THAN 1.5x10EXP-2		LESS THAN 1.5x10EXP-1		LESS THAN 1.5x10EXP+0		LESS THAN 1.5x10EXP+1	
JUN	242.06	34.78	253.07	36.36	264.11	37.95	276.67	39.75
SEP	292.91	42.08	314.61	45.20	323.49	46.48	334.56	48.07
DEC	331.92	47.69	365.07	52.45	375.96	54.02	387.55	55.68
MAR	290.27	41.71	312.45	44.89	322.16	46.29	333.13	47.86

Latitude 60

	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
	LESS THAN 1.5x10EXP-6		LESS THAN 1.5x10EXP-5		LESS THAN 1.5x10EXP-4		LESS THAN 1.5x10EXP-3	
JUN	.00	.00	.00	.00	.00	.00	.00	.00
SEP	87.23	12.53	94.69	13.61	119.96	17.24	181.27	26.05
DEC	170.67	24.52	180.07	25.87	208.70	30.00	278.38	40.00
MAR	94.21	13.54	100.40	14.43	124.98	17.96	179.4[illegible]	25.78
	LESS THAN 1.5x10EXP-2		LESS THAN 1.5x10EXP-1		LESS THAN 1.5x10EXP+0		LESS THAN 1.5x10EXP+1	
JUN	.00	.00	5.12	.74	81.45	11.70	123.99	17.81
SEP	277.98	39.94	295.33	42.43	311.32	44.73	329.73	47.38
DEC	423.07	60.79	456.11	65.53	475.96	68.39	500.38	71.89
MAR	272.58	39.16	290.22	41.70	306.28	44.01	324.81	46.67

TABLE 1

Number of Hours in which Illumination
Exceeds a Given Level

Zero-Degree Latitude

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
MAY 20	14.75	61.44	14.70	61.25	14.31	59.62	13.79	57.44
MAY 21	14.75	61.44	14.70	61.25	14.31	59.63	13.78	57.43
MAY 22	15.44	64.32	14.73	61.36	14.32	59.67	13.78	57.42
MAY 23	16.49	68.73	16.01	66.71	14.46	60.24	13.78	57.42
MAY 24	17.53	73.06	17.18	71.58	15.78	65.76	13.78	57.44
MAY 25	18.48	77.02	18.19	75.79	17.20	71.66	13.79	57.47
MAY 26	19.42	80.92	19.13	79.72	18.34	76.40	14.46	60.27
MAY 27	20.22	84.27	19.96	83.18	19.33	80.53	16.82	70.08
MAY 28	20.99	87.46	20.78	86.58	20.23	84.30	18.32	76.31
MAY 29	21.74	90.60	21.58	89.93	21.05	87.72	19.47	81.15
MAY 30	22.50	93.74	22.37	93.21	21.87	91.14	20.53	85.53
MAY 31	23.35	97.31	23.16	96.52	22.69	94.55	21.53	89.71
JUN 1	24.00	100.00	23.97	99.87	23.52	97.99	22.51	93.79
JUN 2	24.00	100.00	24.00	100.00	24.00	100.00	23.52	98.01

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x10EXP-0		GREATER THAN 1.5x 10EXP-1	
MAY 20	13.44	55.99	13.1[illegible]	54.72	12.87	53.61	12.45	51.88
MAY 21	13.44	55.99	13.14	54.75	12.86	53.60	12.45	51.88
MAY 22	13.44	55.98	13.14	54.77	12.86	53.59	12.45	51.89
MAY 23	13.43	55.98	13.15	54.79	12.86	53.57	12.46	51.93
MAY 24	13.43	55.97	13.16	54.81	12.85	53.55	12.47	51.96
MAY 25	13.43	55.96	13.16	54.84	12.85	53.53	12.48	51.99
MAY 26	13.43	55.95	13.17	54.86	12.84	53.50	12.48	52.02
MAY 27	13.42	55.94	13.17	54.88	12.83	53.47	12.49	52.05
MAY 28	13.46	56.01	13.18	54.90	12.83	53.44	12.50	52.07
MAY 29	13.48	56.17	13.18	54.91	12.82	53.40	12.50	52.10
MAY 30	13.51	56.30	13.18	54.93	12.81	53.36	12.51	52.13
MAY 31	13.53	56.39	13.19	54.95	12.80	53.32	12.52	52.15
JUN 1	13.54	56.43	13.19	54.96	12.78	53.27	12.52	52.16
JUN 2	17.98	74.93	13.19	54.96	12.77	53.21	12.52	52.18

Zero deg: Page 1

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JUN 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~JUN 4~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 5	24.00	100.00	24.00	100.00	23.62	98.40	22.59	94.14
~~JUN 6~~	23.33	97.22	23.14	96.41	22.61	94.22	21.43	89.31
JUN 7	22.41	93.36	22.17	92.36	21.63	90.12	20.24	84.34
JUN 8	21.47	89.46	21.21	88.38	20.68	86.19	19.08	79.49
JUN 9	20.60	85.85	20.37	84.90	19.77	82.37	17.87	74.46
JUN 10	19.74	82.24	19.49	81.23	18.87	78.64	16.46	68.58
JUN 11	18.97	79.05	18.70	77.92	17.97	74.87	14.65	61.02
~~JUN 12~~	18.20	75.84	17.91	74.62	16.99	70.79	13.86	57.74
JUN 13	17.41	72.55	17.07	71.11	15.84	65.98	13.76	57.34
JUN 14	16.52	68.84	16.10	67.09	14.51	60.47	13.77	57.39
JUN 15	15.64	65.17	14.92	62.18	14.36	59.83	13.79	57.44
JUN 16	14.75	61.44	14.71	61.28	14.33	59.72	13.80	57.50

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN 3	19.49	81.21	13.19	54.97	12.76	53.15	12.53	52.19
JUN 4	17.84	74.35	13.19	54.98	12.74	53.10	12.53	52.20
JUN 5	13.52	56.33	13.20	54.98	12.74	53.10	12.53	52.21
JUN 6	13.53	56.36	13.20	54.99	12.75	53.10	12.53	52.21
JUN 7	13.53	56.36	13.20	54.99	12.75	53.10	12.53	52.22
JUN 8	13.52	56.33	13.20	54.99	12.75	53.10	12.53	52.21
JUN 9	13.51	56.28	13.20	54.99	12.75	53.10	12.53	52.21
JUN 10	13.49	56.21	13.20	54.98	12.76	53.16	12.53	52.20
JUN 11	13.47	56.13	13.19	54.97	12.78	53.23	12.52	52.19
JUN 12	13.45	56.04	13.19	54.96	12.79	53.31	12.52	52.17
JUN 13	13.44	55.98	13.19	54.95	12.81	53.37	12.52	52.15
JUN 14	13.42	55.93	13.18	54.93	12.82	53.43	12.51	52.13
JUN 15	13.43	55.96	13.18	54.92	12.84	53.49	12.50	52.09
JUN 16	13.44	55.98	13.17	54.90	12.85	53.54	12.49	52.05

Zero deg: Page 2

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JUN 17	14.75	61.44	14.71	61.28	14.34	59.73	13.81	57.55
JUN 18	14.75	61.44	14.71	61.28	14.34	59.75	13.82	57.59
JUN 19	14.99	62.47	14.93	62.21	14.40	60.01	13.83	57.63
JUN 20	15.07	62.78	14.94	62.23	14.41	60.05	13.84	57.67
JUN 21	16.17	67.37	15.53	64.71	14.47	60.29	13.85	57.72
JUN 22	17.15	71.45	16.71	69.61	14.86	61.90	13.87	57.80
JUN 23	17.99	74.94	17.67	73.61	16.44	68.50	13.91	57.95
JUN 24	18.85	78.53	18.55	77.30	17.61	73.37	14.01	58.36
JUN 25	19.65	81.89	19.37	80.73	18.58	77.43	15.67	65.31
JUN 26	20.43	85.12	20.16	83.99	19.46	81.07	17.31	72.14
JUN 27	21.20	88.35	20.94	87.23	20.32	84.66	18.60	77.48
JUN 28	21.98	91.58	21.72	90.49	21.16	88.16	19.71	82.12
JUN 29	22.85	95.20	22.63	94.31	22.05	91.88	20.78	86.60
JUN 30	23.73	98.89	23.50	97.90	22.94	95.60	21.87	91.11

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN 17	13.44	56.01	13.17	54.87	12.86	53.58	12.48	52.01
JUN 18	13.45	56.03	13.16	54.85	12.87	53.62	12.47	51.96
JUN 19	13.45	56.04	13.16	54.81	12.88	53.65	12.46	51.91
JUN 20	13.45	56.06	13.15	54.78	12.88	53.68	12.45	51.89
JUN 21	13.46	56.07	13.14	54.74	12.89	53.70	12.46	51.90
JUN 22	13.46	56.09	13.13	54.70	12.89	53.73	12.46	51.90
JUN 23	13.46	56.10	13.12	54.65	12.90	53.75	12.46	51.91
JUN 24	13.47	56.11	13.10	54.59	12.90	53.76	12.46	51 91
JUN 25	13.47	56.13	13.09	54.54	12.91	53.77	12.46	51.91
JUN 26	13.47	56.14	13.07	54.47	12.91	53.78	12.46	51.91
JUN 27	13.48	56.15	13.06	54.40	12.91	53.79	12.46	51.92
JUN 28	13.48	56.16	13.06	54.42	12.91	53.79	12.46	51.92
JUN 29	13.48	56.16	13.06	54.41	12.91	53.79	12.46	51.92
JUN 30	13.48	56.16	13.06	54.43	12.91	53.79	12.46	51.92

Zero deg: Page 3

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6		GREATER THAN 1.5x10EXP=5		GREATER THAN 1.5x10EXP=4		GREATER THAN 1.5x10EXP=3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JUL 1	24.00	100.00	24.00	100.00	24.00	100.00	22.95	95.61
JUL 2	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 4	24.00	100.00	24.00	100.00	24.00	100.00	23.18	96.59
JUL 5	23.94	99.77	23.69	98.71	23.17	96.53	22.13	92.19
JUL 6	22.99	95.79	22.81	95.05	22.25	92.71	21.07	87.78
JUL 7	22.21	92.54	21.95	91.45	21.39	89.14	20.01	83.35
JUL 8	21.42	89.27	21.17	88.20	20.56	85.66	18.91	78.81
JUL 9	20.65	86.03	20.39	84.96	19.72	82.15	17.71	73.81
JUL 10	19.86	82.75	19.60	81.66	18.84	78.50	16.13	67.22
JUL 11	19.02	79.26	18.76	78.16	17.88	74.51	14.06	58.60
JUL 12	18.22	75.90	17.89	74.55	16.73	69.71	13.89	57.86
JUL 13	17.32	72.17	16.91	70.47	15.22	63.42	13.82	57.57
JUL 14	16.36	68.15	15.78	65.75	14.39	59.96	13.77	57.39

	GREATER THAN 1.5x10EXP=2		GREATER THAN 1.5x10EXP=1		GREATER THAN 1.5x 10EXP=0		GREATER THAN 1.5x 10EXP-1	
JUL 1	14.72	61.32	13.08	54.48	12.91	53.78	12.46	51.91
JUL 2	18.33	76.38	13.09	54.53	12.90	53.77	12.46	51.91
JUL 3	18.73	78.05	13.10	94.57	12.90	53.76	12.46	51.91
JUL 4	16.31	67.97	13.11	54.61	12.90	53.75	12.46	51.9[illegible]
JUL 5	13.48	56.17	13.12	54.65	12.90	53.73	12.46	51.90
JUL 6	13.48	56.16	13.12	54.69	12.89	53.71	12.46	51.90
JUL 7	13.47	56.14	13.13	54.72	12.88	53.69	12.45	51.89
JUL 8	13.47	56.12	13.14	54.75	12.88	53.66	12.45	51.89
JUL 9	13.46	56.08	~~13.15~~	54.78	12.87	53.64	12.45	51.88
JUL 10	13.45	56.05	13.15	54.80	12.87	53.61	12.46	51.91
JUL 11	13.44	56.02	13.16	54.82	12.86	53.58	12.47	51.95
JUL 12	13.44	55.99	13.16	54.84	12.85	53.55	12.48	51.99
JUL 13	13.43	55.96	13.17	54.86	12.84	53.51	12.48	52.02
JUL 14	13.42	55.94	13.17	54.87	12.83	53.48	12.49	52.04

Zero deg: Page 4

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-3 HOURS	TIME O/O
JUL 15	15.25	63.52	14.71	61.30	14.32	59.66	13.75	57.29
JUL 16	14.75	61.44	14.70	61.26	14.30	59.58	13.73	57.22
JUL 17	14.75	61.44	14.70	61.26	14.29	59.56	13.73	57.22
JUL 18	14.75	61.44	14.70	61.26	14.29	59.54	13.73	57.22
JUL 19	14.75	61.44	14.70	61.26	14.29	59.53	13.73	57.22
JUL 20	15.41	64.22	14.72	61.35	14.29	59.54	13.73	57.22
JUL 21	16.34	68.05	15.85	66.05	14.42	60.08	13.73	57.23
JUL 22	17.19	71.61	16.83	70.13	15.48	64.49	13.74	57.25
JUL 23	17.97	74.86	17.67	73.62	16.67	69.48	13.76	57.34
JUL 24	18.73	78.06	18.46	76.91	17.67	73.64	14.16	59.01
JUL 25	19.54	81.38	19.31	80.45	18.61	77.53	16.07	66.96
JUL 26	20.43	85.12	20.15	84.02	19.52	81.33	17.53	73.05
JUL 27	21.24	88.51	21.04	87.67	20.45	85.21	18.77	78.21
JUL 28	22.22	92.59	21.96	91.51	21.42	89.25	20.00	83.33

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP+1 HOURS	TIME O/O
JUL 15	13.42	55.91	13.17	54.88	12.83	53.44	12.49	52.06
JUL 16	13.41	55.89	13.17	54.89	12.82	53.40	12.50	52.08
JUL 17	13.41	55.87	13.18	54.90	12.81	53.36	12.50	52.10
JUL 18	13.40	55.84	13.18	54.91	12.80	53.32	12.51	52.12
JUL 19	13.40	55.82	13.18	54.91	12.79	53.28	12.51	52.13
JUL 20	13.39	55.79	13.18	54.92	12.78	53.23	12.51	52.14
JUL 21	13.38	55.77	13.18	54.92	12.77	53.19	12.52	52.15
JUL 22	13.38	55.75	13.18	54.92	12.76	53.15	12.52	52.15
JUL 23	13.38	55.77	13.18	54.93	12.75	53.11	12.52	52.16
JUL 24	13.40	55.82	13.18	54.93	12.74	53.09	12.52	52.16
JUL 25	13.41	55.87	13.18	54.93	12.74	53.09	12.52	52.16
JUL 26	13.43	55.95	13.18	54.93	12.74	53.09	12.52	52.17
JUL 27	13.44	56.02	13.18	54.93	12.74	53.09	12.52	52.17
JUL 28	13.46	56.08	13.18	54.93	12.74	53.09	12.52	52.17

Zero deg: Page 5

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JUL 29	23.21	96.69	22.95	95.62	22.42	93.43	21.22	88.40
~~JUL 30~~	24.00	100.00	23.95	99.80	23.43	97.63	22.39	93.31
JUL 31	24.00	100.00	24.00	100.00	24.00	100.00	23.52	97.99
~~AUG 1~~	24.00	100.00	24.00	100.0	24.00	100.00	24.00	100.00
AUG 2	24.00	100.00	24.00	100.0	24.00	100.00	23.72	98.84
~~AUG 3~~	24.00	100.00	24.00	100.00	23.67	98.62	22.72	94.68
AUG 4	23.50	97.90	23.36	97.33	22.84	95.17	21.77	90.72
~~AUG 5~~	22.74	94.75	22.56	94.01	22.01	91.72	20.78	86.58
AUG 6	21.99	91.61	21.77	90.70	21.21	88.37	19.75	82.29
~~AUG 7~~	21.23	88.45	20.97	87.36	20.38	84.93	18.60	77.50
AUG 8	20.45	85.22	20.18	84.07	19.47	81.14	17.12	71.34
~~AUG 9~~	19.60	81.67	19.32	80.48	18.48	76.99	15.02	62.60
AUG 10	18.70	77.92	18.38	76.59	17.35	72.29	13.84	57.67
~~AUG 11~~	17.71	73.81	17.35	72.30	15.95	66.48	13.73	57.20

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP-0		GREATER THAN 1.5x10EXP+1	
JUL 29	13.47	56.11	13.18	54.93	12.74	53.09	12.52	52.17
~~JUL 30~~	13.46	56.10	13.16	54.93	12.74	53.09	12.52	52.17
JUL 31	17.03	70.97	13.18	54.93	12.74	53.09	12.52	52.17
AUG 1	19.05	79.39	13.18	54.92	12.74	53.09	12.52	52.17
AUG 2	18.29	76.19	13.18	54.92	12.74	53.09	12.52	52.17
AUG 3	14.96	62.35	13.18	54.92	12.74	53.09	12.52	52.17
AUG 4	13.42	55.91	13.16	54.92	12.74	53.09	12.52	52.16
AUG 5	13.41	55.86	13.18	54.91	12.74	53.09	12.52	52.16
AUG 6	13.39	55.78	13.18	54.91	12.74	53.09	12.52	52.16
AUG 7	13.37	55.71	13.18	54.90	12.74	53.09	12.52	52.16
AUG 8	13.35	55.64	13.18	54.90	12.74	53.08	12.52	52.15
AUG 9	13.34	55.58	13.17	54.89	12.74	53.08	12.52	52.15
AUG 10	13.33	55.54	13.17	54.89	12.74	53.08	12.51	52.14
AUG 11	13.32	55.52	13.17	54.88	12.74	53.08	12.51	52.14

Zero deg: Page 6

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
AUG 12	16.7[illegible]	69.56	16.20	67.51	14.42	60.09	13.72	57.18
AUG 13	15.64	65.18	14.91	62.13	14.26	59.42	13.72	57.17
AUG 14	14.76	61.44	14.69	61.22	14.23	59.29	13.72	57.17
AUG 15	14.74	61.43	14.69	61.21	14.23	59.28	13.72	57.16
AUG 16	14.74	61.43	14.69	61.21	14.23	59.27	13.72	57.16
AUG 17	14.74	61.43	14.69	61.21	14.22	59.27	13.72	57.15
AUG 18	14.76	61.52	14.69	61.23	14.23	59.27	13.72	57.15
AUG 19	15.69	65.37	15.09	62.89	14.25	59.36	13.72	57.15
AUG 20	16.49	68.71	16.11	67.13	14.46	60.25	13.72	57.16
AUG 21	17.36	72.33	17.01	70.88	15.78	65.76	13.73	57.19
AUG 22	18.2[illegible]	75.83	17.90	74.57	16.94	70.60	13.74	57.27
AUG 23	19.04	79.35	18.78	78.26	17.99	74.94	14.69	61.19
AUG 24	19.96	83.23	19.71	82.11	19.01	79.20	16.61	69.20
AUG 25	20.96	87.34	20.69	86.21	20.06	83.58	18.15	75.64

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
AUG 12	13.32	55.51	13.17	54.88	12.74	53.08	12.51	52.13
AUG 13	13.32	55.51	13.17	54.87	12.74	53.08	12.51	52.13
AUG 14	13.33	55.52	13.17	54.86	12.74	53.08	12.51	52.12
AUG 15	13.33	55.54	13.16	54.85	12.74	53.08	12.51	52.11
AUG 16	13.33	55.55	13.16	54.84	12.74	53.08	12.51	52.11
AUG 17	13.34	55.56	13.16	54.83	12.74	53.08	12.50	52.10
AUG 18	13.34	55.58	13.16	54.82	12.74	53.08	12.50	52.08
AUG 19	13.34	55.60	13.15	54.81	12.74	53.07	12.50	52.07
AUG 20	13.35	55.62	13.15	54.79	12.74	53.10	12.49	52.05
AUG 21	13.35	55.64	13.15	54.78	12.75	53.14	12.49	52.02
AUG 22	13.36	55.66	13.14	54.76	12.76	53.17	12.48	52.00
AUG 23	13.37	55.69	13.14	54.74	12.77	53.22	12.47	51.98
AUG 24	13.37	55.71	13.13	54.72	12.78	53.26	12.47	51.95
AUG 25	13.38	55.74	13.13	54.70	12.79	53.29	12.46	51.91

Zero deg: Page 7

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6		GREATER THAN 1.5x10EXP=5		GREATER THAN 1.5x 10EXP=4		GREATER THAN .5x10EXP=3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
AUG 26	21.95	91.46	21.69	90.36	21.10	87.92	19.52	81.32
AUG 27	22.93	95.53	22.68	94.48	22.13	92.20	20.80	86.69
AUG 28	23.81	99.22	23.64	98.49	23.12	96.32	22.01	91.70
AUG 29	24.00	100.00	24.00	100.00	24.00	100.00	23.09	96.21
AUG 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 31	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 1	24.00	100.00	24.00	100.00	24.00	100.00	23.33	97.21
SEP 2	23.94	99.75	23.71	98.80	23.33	97.20	22.42	93.40
SEP 3	23.18	96.57	22.95	95.62	22.54	93.90	21.45	89.38
SEP 4	22.38	93.26	22.17	92.37	21.71	90.44	20.38	84.93
SEP 5	21.50	89.56	21.32	88.85	20.81	86.72	19.18	79.91
SEP 6	20.70	86.25	20.44	85.15	19.85	82.72	17.77	74.05
SEP 7	19.73	82.22	19.47	81.11	18.79	78.31	15.85	66.03
SEP 8	18.74	78.10	18.47	76.95	17.64	73.49	13.85	57.71

	GREATER THAN 1.5x 10EXP=2		GREATER THAN 1.5x10EXP=1		GREATER THAN 1.5x10EXP=0		GREATER THAN 1.5x 10EXP-1	
AUG 26	13.38	55.76	13.12	54.67	12.80	53.33	12.45	51.88
AUG 27	13.39	55.79	13.11	54.64	12.81	53.37	12.44	51.84
AUG 28	13.40	55.81	13.10	54.60	12.82	53.41	12.44	51.85
AUG 29	15.26	63.57	13.09	54.56	12.83	53.44	12.44	51.85
AUG 30	18.79	78.29	13.08	54.50	12.83	53.48	12.45	51.86
AUG 31	19.47	81.11	13.06	54.44	12.84	53.51	12.45	51.86
SEP 1	17.89	74.56	13.05	54.37	12.85	53.54	12.45	51.87
SEP 2	13.45	56.05	13.03	54.30	12.85	53.56	12.45	51.87
SEP 3	13.45	56.04	13.01	54.23	12.86	53.58	12.45	51.87
SEP 4	13.45	56.02	12.99	54.14	12.86	53.60	12.45	51.88
SEP 5	13.44	56.00	12.99	54.14	12.87	53.61	12.45	51.88
SEP 6	13.43	55.98	12.99	54.14	12.87	53.63	12.45	51.88
SEP 7	13.43	55.96	12.99	54.14	12.87	53.64	12.45	51.88
SEP 8	13.43	55.95	12.99	54.14	12.88	53.65	12.45	51.89

Zero deg: Page 8

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	GREATER THAN 1.5x10EXP-6 TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	GREATER THAN 1.5x10EXP-5 TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	GREATER THAN 1.5x10EXP-4 TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	GREATER THAN 1.5x10EXP-3 TIME 0/0
SEP 9	17.74	73.93	17.44	72.65	16.32	67.99	13.75	57.31
SEP 10	16.74	69.75	16.37	68.22	14.74	61.40	13.70	57.09
SEP 11	15.74	65.60	15.23	63.47	14.21	59.21	13.68	56.99
SEP 12	14.77	61.58	14.47	60.29	14.15	58.98	13.67	56.95
SEP 13	14.50	60.40	14.46	60.27	14.14	58.94	13.66	56.92
SEP 14	14.50	60.40	14.46	60.27	14.14	58.93	13.65	56.89
SEP 15	14.50	60.40	14.46	60.27	14.14	58.93	13.64	56.85
SEP 16	14.50	60.40	14.46	60.27	14.14	58.92	13.64	56.85
SEP 17	14.98	62.42	14.48	60.32	14.16	58.99	13.65	56.89
SEP 18	15.92	66.32	15.41	64.21	14.25	59.36	13.66	56.92
SEP 19	16.79	69.96	16.44	68.49	15.03	62.63	13.67	56.95
SEP 20	17.97	74.87	17.84	73.40	16.45	68.56	13.75	57.30
SEP 21	18.95	78.96	18.64	77.65	17.67	73.62	13.92	57.99
SEP 22	19.95	83.11	19.65	81.86	18.83	78.44	15.89	66.22

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	GREATER THAN 1.5x10EXP-2 TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	GREATER THAN 1.5x10EXP-1 TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	GREATER THAN 1.5x10EXP+0 TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	GREATER THAN 1.5x10EXP+1 TIME 0/0
SEP 9	13.43	55.94	12.99	54.14	12.88	53.65	12.45	51.89
SEP 10	13.43	55.94	12.99	54.14	12.88	53.65	12.45	51.89
SEP 11	13.42	55.96	12.99	54.14	12.88	53.65	12.45	51.89
SEP 12	13.42	55.94	12.99	54.14	12.87	53.64	12.45	51.88
SEP 13	13.42	55.92	12.99	54.14	12.87	53.63	12.45	51.88
SEP 14	13.42	55.91	12.99	54.14	12.87	53.62	12.45	51.88
SEP 15	13.42	55.90	12.99	54.14	12.86	53.60	12.45	51.88
SEP 16	13.41	55.88	12.99	54.14	12.86	53.58	12.45	51.87
SEP 17	13.41	55.86	13.01	54.23	12.85	53.55	12.45	51.87
SEP 18	13.40	55.84	13.03	54.31	12.84	53.52	12.45	51.86
SEP 19	13.40	55.82	13.05	54.38	12.84	53.48	12.45	51.86
SEP 20	13.39	55.80	13.07	54.45	12.82	53.43	12.44	51.85
SEP 21	13.39	55.79	13.08	54.51	12.81	53.38	12.44	51.85
SEP 22	13.39	55.79	13.09	54.56	12.80	53.33	12.44	51.84

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
SEP 23	20.94	87.24	20.65	86.04	19.92	83.02	17.78	74.07
SEP 24	21.89	91.21	21.63	90.11	20.96	87.33	19.24	80.18
SEP 25	22.74	94.74	22.53	93.88	21.93	91.38	20.55	85.64
SEP 26	23.65	98.55	23.41	97.55	22.86	95.24	21.71	90.45
SEP 27	24.00	100.00	24.00	100.00	23.69	98.71	22.74	94.73
SEP 28	24.00	100.00	24.00	100.00	24.00	100.00	23.72	98.82
SEP 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 1	24.00	100.00	24.00	100.00	23.99	99.95	22.92	95.50
OCT 2	23.73	98.86	23.47	97.77	22.97	95.71	21.93	91.38
OCT 3	22.91	95.44	22.66	94.42	22.10	92.09	20.81	86.71
OCT 4	21.98	91.57	21.71	90.46	21.14	88.07	19.57	81.54
OCT 5	20.99	87.47	20.77	86.53	20.12	83.83	18.18	75.75
OCT 6	20.01	83.39	19.77	82.36	19.03	79.31	16.49	68.72

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O
SEP 23	13.39	55.80	13.11	54.61	12.78	53.27	12.45	51.86
SEP 24	13.40	55.82	13.12	54.65	12.77	53.20	12.46	51.91
SEP 25	13.40	55.83	13.13	54.69	12.75	53.13	12.47	51.96
SEP 26	13.40	55.84	13.14	54.72	12.73	53.06	12.48	52.00
SEP 27	13.40	55.82	13.14	54.75	12.74	53.06	12.49	52.03
SEP 28	18.10	75.41	13.15	54.77	12.74	53.07	12.49	52.06
SEP 29	19.69	82.04	13.15	54.80	12.74	53.07	12.50	52.08
SEP 30	18.88	78.67	13.15	54.81	12.74	53.07	12.50	52.10
OCT 1	15.89	66.22	13.16	54.83	12.74	53.07	12.51	52.11
OCT 2	13.32	55.49	13.16	54.83	12.74	53.07	12.51	52.12
OCT 3	13.32	55.49	13.16	54.84	12.74	53.07	12.51	52.12
OCT 4	13.31	55.46	13.16	54.84	12.74	53.07	12.51	52.12
OCT 5	13.30	55.43	13.16	54.83	12.74	53.07	12.51	52.12
OCT 6	13.30	55.40	13.16	54.83	12.74	53.07	12.51	52.12

Zero deg: Page 10

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
OCT 7	19.06	79.40	18.76	78.17	17.91	74.64	14.26	59.43
OCT 8	18.12	75.50	17.79	74.12	16.77	69.86	13.76	57.35
OCT 9	17.18	71.60	16.82	70.07	15.48	64.49	13.72	57.15
OCT 10	16.24	67.67	15.82	65.93	14.38	59.90	13.71	57.13
OCT 11	15.41	64.19	14.75	61.45	14.23	59.31	13.71	57.12
OCT 12	14.74	61.43	14.69	61.20	14.21	59.22	13.71	57.11
OCT 13	14.74	61.43	14.69	61.20	14.21	59.21	13.71	57.11
OCT 14	14.74	61.43	14.69	61.20	14.21	59.21	13.70	57.10
OCT 15	14.74	61.43	14.69	61.20	14.21	59.21	13.70	57.09
OCT 16	14.75	61.44	14.69	61.21	14.21	59.23	13.70	57.09
OCT 17	15.63	65.14	14.96	62.32	14.24	59.35	13.70	57.09
OCT 18	16.63	69.31	16.16	67.35	14.44	60.17	13.71	57.11
OCT 19	17.65	73.56	17.27	71.98	15.93	66.34	13.72	57.16
OCT 20	18.67	77.80	18.35	76.45	17.35	72.27	13.74	57.26

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x10EXP+1	
OCT 7	13.30	55,40	13.16	54.82	12.74	53,07	12.51	52,11
OCT 8	13.30	55,42	13.16	54,81	12.74	53,07	12.50	52,10
OCT 9	13.31	55,45	13.15	54.80	12.74	53,07	12.50	52,09
OCT 10	13.32	55,50	13.15	54.79	12.74	53,07	12.50	52,07
OCT 11	13.33	55,54	13.15	54,78	12.74	53,07	12,49	52,05
OCT 12	13.34	55,58	13.14	54,76	12.74	53,07	12,49	52,02
OCT 13	13,35	55,63	13.14	54.75	12.75	53,14	12,48	52,00
OCT 14	13,36	55,67	13.14	54.73	12.77	53,20	12.47	51,98
OCT 15	13.37	55,70	13.13	54.71	12.78	53,25	12.47	51,95
OCT 16	13.38	55,73	13.13	54,69	12.79	53,30	12.46	51,92
OCT 17	13.38	55,76	13.12	54.67	12.80	53,34	12,45	51,89
OCT 18	13.39	55,79	13.12	54.65	12.81	53,38	12,45	51,86
OCT 19	13.40	55,81	13.11	54.63	12.82	53,41	12,44	51,85
OCT 20	13.40	55,84	13.11	54.61	12.83	53,45	12,44	51,85

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
OCT 21	19.66	81.91	19.36	80.68	18.54	77.27	14.90	62.09
~~OCT 22~~	20.55	85.62	20.31	84.64	19.64	81.82	17.19	71.61
OCT 23	21.46	89.43	21.20	88.34	20.63	85.99	18.77	78.22
~~OCT 24~~	22.24	92.67	22.05	91.88	21.52	89.67	20.02	83.40
OCT 25	23.00	95.82	22.87	95.30	22.37	93.22	21.11	87.98
OCT 26	23.78	99.09	23.65	98.94	23.19	96.61	22.12	92.17
OCT 27	24.00	100.00	24.00	100.00	24.00	100.00	23.04	96.01
OCT 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 30	24.00	100.00	24.00	100.00	24.00	100.00	23.46	97.75
OCT 31	24.00	100.00	23.97	99.87	23.41	97.55	22.39	93.31
NOV 1	23.24	96.82	23.02	95.92	22.44	93.48	21.23	88.47
NOV 2	22.25	92.69	22.06	91.91	21.43	89.28	19.97	83.20
~~NOV 3~~	21.29	88.72	21.07	87.78	20.40	85.00	18.63	77.62

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
OCT 21	13.41	55.86	13.10	54.60	12.83	53.47	12.45	51.86
OCT 22	13.41	55.88	13.10	54.59	12.84	53.50	12.45	51.86
OCT 23	13.42	55.90	13.10	54.57	12.85	53.53	12.45	51.86
OCT 24	13.42	55.92	13.09	54.56	12.85	53.54	12.45	51.87
OCT 25	13.43	55.94	13.09	54.55	12.85	53.56	12.45	51.87
OCT 26	13.43	55.96	13.09	54.54	12.86	53.57	12.45	51.87
OCT 27	16.60	69.16	13.09	54.53	12.86	53.59	12.45	51.87
OCT 28	19.09	79.52	13.08	54.51	12.86	53.60	12.45	51.88
OCT 29	19.70	82.10	13.08	54.49	12.87	53.61	12.45	51.88
OCT 30	17.52	72.99	13.07	54.47	12.87	53.62	12.45	51.88
OCT 31	13.46	56.09	13.07	54.47	12.87	53.63	12.45	51.88
NOV 1	13.46	56.09	13.07	54.47	12.87	53.63	12.45	51.88
NOV 2	13.46	56.08	13.07	54.47	12.87	53.64	12.45	51.88
NOV 3	13.46	56.06	13.07	54.47	12.87	53.64	12.45	51.88

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
NOV 4	20.37	84.86	20.10	83.73	19.38	80.74	17.23	71.80
NOV 5	19.44	81.01	19.15	79.79	18.35	76.48	15.53	64.72
NOV 6	18.49	77.06	18.21	75.89	17.34	72.25	13.94	58.09
NOV 7	17.70	73.76	17.38	72.40	16.25	67.71	13.86	57.74
NOV 8	16.90	70.41	16.51	68.77	14.98	62.40	13.81	57.54
NOV 9	16.04	66.82	15.55	64.78	14.36	59.85	13.79	57.45
NOV 10	15.17	63.23	14.71	61.27	14.31	59.61	13.78	57.42
NOV 11	14.74	61.44	14.70	61.24	14.30	59.58	13.78	57.42
NOV 12	14.74	61.44	14.70	61.24	14.30	59.58	13.78	57.43
NOV 13	14.74	61.44	14.70	61.24	14.30	59.59	13.78	57.43
NOV 14	14.74	61.44	14.70	61.25	14.30	59.60	13.79	57.44
NOV 15	15.19	63.27	14.71	61.31	14.31	59.64	13.79	57.44
NOV 16	16.27	67.78	15.74	65.57	14.41	60.03	13.79	57.46
NOV 17	17.35	72.28	16.94	70.60	15.35	63.95	13.80	57.49

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
NOV 4	13.45	56.05	13.07	54.47	12.88	53.65	12.45	51.89
NOV 5	13.45	56.03	13.06	54.48	12.88	53.65	12.45	51.89
NOV 6	13.44	56.02	13.08	54.49	12.88	53.65	12.45	51.89
NOV 7	13.44	56.01	13.08	54.50	12.88	53.65	12.45	51.89
NOV 8	13.44	56.01	13.08	54.51	12.88	53.66	12.45	51.89
NOV 9	13.44	56.01	13.09	54.53	12.88	53.66	12.45	51.89
NOV 10	13.44	56.01	13.09	54.54	12.88	53.66	12.45	51.89
NOV 11	13.44	56.01	13.09	54.56	12.88	53.65	12.45	51.89
NOV 12	13.44	56.01	13.10	54.58	12.88	53.65	12.45	51.89
NOV 13	13.44	56.01	13.10	54.60	12.88	53.65	12.45	51.89
NOV 14	13.44	56.01	13.11	54.62	12.88	53.65	12.45	51.89
NOV 15	13.44	56.01	13.11	54.64	12.87	53.64	12.45	51.88
NOV 16	13.44	56.00	13.12	54.66	12.87	53.64	12.45	51.88
NOV 17	13.44	56.00	13.13	54.69	12.87	53.63	12.45	51.88

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6		GREATER THAN 1.5x10EXP=5		GREATER THAN 1.5x10EXP=4		GREATER THAN 1.5x10EXP=3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
OV 18	18.32	76,32	17.98	74.91	16.92	70,49	13.81	57,55
OV 19	19.23	80,11	18.95	78.96	18.15	75,63	14.10	58,74
OV 20	20.11	83,79	19.86	82.74	19.19	79,94	16.46	68,60
OV 21	20.93	87,22	20.68	86.16	20.10	83,75	18.12	75;52
OV 22	21.70	90,42	21.45	89.38	20.95	87,28	19.34	80.57
OV 23	22.46	93,58	22.21	92.55	21.75	90,64	20.41	85.05
OV 24	23.22	96,76	22.98	95.73	22.55	93,95	21.41	89,21
OV 25	23.99	99,95	23.82	99.23	23.38	97,42	22.37	93,20
OV 26	24.00	100,00	24,00	100.00	24.00	100,00	23.34	97,24
OV 27	24.00	100,00	24.00	100.00	24.00	100,00	24.00	100.00
OV 28	24.00	100.00	24.00	100.00	24.00	100,00	24.00	100.00
OV 29	24.00	100,00	24.00	100.00	24.00	100,00	22.84	95.15
OV 30	23.50	97,90	23,35	97.29	22.80	95,00	21.68	90,31
EC 1	22.57	94,03	22.37	93.21	21.79	90,80	20.47	85.27

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP=2		GREATER THAN 1.5x10EXP=1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x 10EXP+1	
NOV 13	13,44	56,00	13.13	54.71	12.87	53,62	12.45	51,88
NOV 19	13,44	56,00	13.14	54.74	12.87	53,60	12.45	51,88
NOV 20	13,44	55,99	13.14	54.77	12.86	53,59	12.45	51,88
NOV 21	13,44	55,99	13.15	54.79	12.86	53,58	12.46	51,91
NOV 22	13,44	55,98	13.16	54.82	12.85	53,56	12.47	51,94
NOV 23	13,46	56,08	13.16	54.84	12.65	53,54	12.47	51,97
NOV 24	13,49	56,23	13.17	54.86	12.84	53,51	12.48	52,00
NOV 25	13,51	56,30	13.17	54.88	12.84	53,49	12.49	52,03
NOV 26	17,59	73,28	13.17	54.89	12.83	53,45	12.49	52,06
NOV 27	19,30	80,40	13.18	54.90	12.82	53,42	12.50	52,09
NOV 28	18,27	76,12	13.18	54.92	12.81	53,38	12,51	52,11
NOV 29	13,46	56,06	13.18	54.93	12.80	53,34	12,51	52,14
NOV 30	13,46	56,08	13.19	54.94	12.79	53,30	12,52	52,15
DEC 1	13,47	56,13	13.19	54.96	12.78	53,24	12,52	52,17

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
DEC 2	21.67	90.28	21.41	89.23	20.82	86.76	19.27	80.29
DEC 3	20.75	86.38	20.47	85.3[illegible]	19.89	82.87	18.06	75.26
DEC 4	19.93	83.03	19.66	81.92	18.97	79.06	16.70	69.56
DEC 5	19.11	79.62	18.85	78.52	18.07	75.30	14.94	62.26
DEC 6	18.29	76.20	18.02	75.08	17.12	71.35	13.92	58.02
DEC 7	17.49	72.87	17.19	71.60	15.99	66.63	13.76	57.34
DEC 8	16.70	69.59	16.28	67.82	14.52	60.51	13.74	57.26
DEC 9	15.92	65.90	15.19	63.29	14.37	59.67	13.74	57.26
DEC 10	14.80	61.67	14.71	61.29	14.32	59.68	13.74	57.25
DEC 11	14.75	61.44	14.71	61.28	14.31	59.63	13.74	57.25
DEC 12	14.75	61.44	14.71	61.28	14.32	59.65	13.75	57.27
DEC 13	14.75	61.44	14.71	61.28	14.32	59.67	13.76	57.34
DEC 14	14.81	61.70	14.71	61.29	14.33	59.70	13.78	57.41
DEC 15	15.95	66.45	15.26	63.57	14.37	59.87	13.80	57.50

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
DEC 2	13.49	56.15	13.19	54.97	12.76	53.19	12.52	52.18
DEC 3	13.48	56.15	13.19	54.97	12.75	53.12	12.53	52.19
DEC 4	13.48	56.15	13.19	54.98	12.74	53.10	12.53	52.21
DEC 5	13.47	56.13	13.20	54.98	12.74	53.10	12.53	52.21
DEC 6	13.47	56.11	13.20	54.98	12.75	53.10	12.53	52.22
DEC 7	13.46	56.09	13.20	54.99	12.75	53.10	12.53	52.22
DEC 8	13.46	56.08	13.20	54.98	12.75	53.10	12.53	52.21
DEC 9	13.46	56.06	13.20	54.98	12.75	53.11	12.53	52.20
DEC 10	13.45	56.04	13.19	54.97	12.77	53.19	12.53	52.19
DEC 11	13.44	56.01	13.19	54.97	12.78	53.27	12.52	52.18
DEC 12	13.43	55.97	13.19	54.96	12.80	53.34	12.52	52.16
DEC 13	13.42	55.92	13.19	54.94	12.82	53.40	12.51	52.14
DEC 14	13.43	55.94	13.18	54.93	12.83	53.46	12.51	52.11
DEC 15	13.43	55.97	13.18	54.91	12.84	53.51	12.50	52.07

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
DEC 16	16.95	70.63	16.49	68.70	14.49	60.36	13.83	57.62
DEC 17	17.89	74.53	17.52	73.00	16.22	67.56	13.88	57.84
DEC 18	18.72	77.98	18.42	76.73	17.46	72.74	13.96	58.15
DEC 19	19.48	81.18	19.21	80.05	18.45	76.88	15.29	63.72
DEC 20	20.24	84.34	20.02	83.41	19.35	80.61	17.10	71.25
DEC 21	21.00	87.48	20.82	86.77	20.19	84.14	18.43	76.80
DEC 22	21.84	91.01	21.63	90.12	21.03	87.62	19.54	81.41
DEC 23	22.70	94.57	22.44	93.49	21.88	91.18	20.60	85.83
DEC 24	23.49	97.89	23.34	97.25	[illegible]	94.94	21.67	90.30
DEC 25	24.00	100.00	24.00	100.00	23.72	98.82	22.74	94.76
DEC 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
DEC 27	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
DEC 28	24.00	100.00	24.00	100.00	24.00	100.00	23.39	97.46
DEC 29	24.00	100.00	23.90	99.60	23.35	97.29	22.30	92.91

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
DEC 16	13.44	56.00	13.17	54.89	12.85	53.56	12.49	52.04
DEC 17	13.45	56.02	13.17	54.86	12.86	53.60	12.48	51.99
DEC 18	13.45	56.05	13.16	54.83	12.87	53.63	12.47	51.94
DEC 19	13.46	56.08	13.15	54.80	12.88	53.67	12.45	51.89
DEC 20	13.47	56.11	13.14	54.76	12.89	53.69	12.45	51.89
DEC 21	13.47	56.13	13.13	54.72	12.89	53.72	12.46	51.90
DEC 22	13.48	56.15	13.12	54.67	12.90	53.74	12.46	51.91
DEC 23	13.48	56.17	13.11	54.63	12.90	53.76	12.46	51.91
DEC 24	13.48	56.17	13.10	54.57	12.90	53.77	12.46	51.91
DEC 25	13.48	56.17	13.08	54.51	12.91	53.78	12.46	51.91
DEC 26	17.89	74.56	13.07	54.44	12.91	53.78	12.46	51.92
DEC 27	18.85	78.56	13.06	54.41	12.91	53.79	12.46	51.92
DEC 28	16.81	70.06	13.06	54.41	12.91	53.79	12.46	51.92
DEC 29	13.48	56.17	13.06	54.41	12.91	53.79	12.46	51.92

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
DEC 30	23.21	96.71	22. 5	95.61	22.40	93.35	21.23	88.44
DEC 31	22.31	92.96	22.12	92.16	21.53	89.69	20.16	83.98
JAN 1	21.49	89.53	21.27	88.62	20.67	86.13	19.07	79.46
JAN 2	20.73	86.37	20.46	85.25	19.85	82.69	17.92	74.66
JAN 3	19.97	83.21	19.69	82.06	18.96	79.08	16.46	68.58
JAN 4	19.20	80.02	18.91	78.80	18.05	75.21	14.37	59.89
JAN 5	18.40	76.69	18.08	75.31	16.98	70.75	13.92	58.00
JAN 6	17.49	72.87	17.14	71.41	15.64	65.16	13.87	57.78
JAN 7	16.56	69.01	16.04	66.83	14.42	60.09	13.83	57.63
JAN 8	15.49	64.54	14.72	61.32	14.34	59.77	13.81	57.55
JAN 9	14.75	61.44	14.70	61.26	14.32	59.69	13.80	57.50
JAN 10	14.75	61.44	14.70	61.26	14.32	59.67	13.79	57.46
JAN 11	14.75	61.44	14.70	61.26	14.32	59.65	13.78	57.41
JAN 12	14.75	61.44	14.70	61.26	14.31	59.63	13.77	57.36

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
DEC 30	13.46	56.17	13.06	54.42	12.91	53.78	12.46	51.91
~~DEC 31~~	13.48	56.16	13.07	54.48	12.91	53.78	12.46	51.91
JAN 1	13.48	56.15	13.09	54.53	12.90	53.77	12.46	51.91
~~JAN 2~~	13.47	56.13	13.10	54.58	12.90	53.75	12.46	51.91
JAN 3	13.47	56.11	13.11	54.63	12.90	53.74	12.46	51.90
~~JAN 4~~	13.46	56.09	13.12	54.67	12.89	53.72	12.46	51.90
JAN 5	13.46	56.07	13.13	54.70	12.89	53.70	12.46	51.90
~~JAN 6~~	13.45	56.05	13.14	54.73	12.88	53.67	12.45	51.89
JAN 7	13.45	56.04	13.14	54.76	12.88	53.65	12.45	51.89
~~JAN 8~~	13.44	56.02	13.15	54.79	12.87	53.63	12.45	51.89
JAN 9	13.44	56.00	13.15	54.81	12.86	53.60	12.46	51.93
~~JAN 10~~	13.44	55.98	13.16	54.83	12.86	53.57	12.47	51.97
JAN 11	13.43	55.96	13.16	54.85	12.85	53.53	12.48	52.00
~~JAN 12~~	13.43	55.94	13.17	54.86	12.84	53.50	12.49	52.03

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
JAN 13	15.22	63,41	14.72	61.32	14.31	59,64	13.75	57.31
~~JAN 14~~	16.19	67,47	15.67	65.30	14.41	60,04	13.74	57.26
JAN 15	17.01	70,87	16.67	69.46	15.16	63,18	13.74	57.24
JAN 16	17.86	74,41	17.54	73.10	16.50	68,73	13.75	57.28
JAN 17	18.66	77,73	18.37	76.55	17.54	73,08	13.99	58,28
JAN 18	19.44	81,00	19.17	79.87	18.47	76,94	15.74	65,60
JAN 19	20.23	84,28	19.97	83.20	19.37	80.71	17.29	72.05
JAN 20	21.10	87,91	20.87	86.97	20.27	84,48	18.54	77.26
JAN 21	21.98	91,60	21.74	90.59	21.22	88.42	19.75	82.28
JAN 22	22.97	95,71	22.71	94.64	22.21	92,54	20.95	87.30
JAN 23	23.96	99,84	23.71	98.79	23.22	96,74	22.14	92,26
JAN 24	24.00	100,00	24.00	100.00	24.00	100.00	23.28	96,98
JAN 25	24.00	100,00	24.00	100.00	24.00	100.00	24.00	100.00
JAN 26	24.00	100,00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP1 HOURS	TIME 0/0
JAN 13	13,42	55,92	13.17	54.87	12.83	53,46	12,49	52,05
JAN 14	13,42	55,90	13.17	54.89	12.82	53,42	12,50	52,07
JAN 15	13,41	55,88	13.17	54.90	12,81	53,38	12,50	52,09
JAN 16	13,41	55,86	13.18	54.90	12.80	53,34	12,51	52,11
JAN 17	13,40	55,85	13.18	54.91	12.79	53,30	12,51	52,12
JAN 18	13,41	55,89	13.18	54.92	12.78	53,25	12,51	52,14
JAN 19	13,44	55,98	13.18	54.93	12,77	53,21	12,51	52,14
JAN 20	13,46	56,08	13.18	54.93	12,76	53,17	12,52	52,15
JAN 21	13,48	56,16	13.18	54.93	12.75	53,13	12,52	52,16
JAN 22	13,49	56,20	13.18	54.94	12.74	53,09	12,52	52,16
JAN 23	13,49	56,20	13.18	54.94	12.74	53,09	12,52	52,16
JAN 24	16,09	67,05	13.18	54.94	12.74	53,09	12,52	52,16
JAN 25	18,78	78,24	13.18	54.93	12.74	53,09	12,52	52,17
JAN 26	18,46	77,00	13.18	54.93	12.74	53,09	12.52	52,17

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
JAN 27	24.00	100.00	24.00	100.00	24.00	100.00	22.88	95.35
JAN 28	23.71	98.79	23.45	97.71	22.95	95.64	21.93	91.36
JAN 29	22.92	95.52	22.68	94.51	22.15	92.30	20.95	87.27
JAN 30	22.16	92.32	21.92	91.32	21.35	88.95	19.93	83.06
JAN 31	21.39	89.12	21.15	88.11	20.52	85.52	18.82	78.40
FEB 1	20.58	85.75	20.34	84.77	19.65	81.89	17.44	72.65
FEB 2	19.74	82.25	19.46	81.10	18.70	77.92	15.52	64.66
FEB 3	18.91	78.79	18.59	77.46	17.60	73.35	13.90	57.93
FEB 4	17.95	74.78	17.59	73.29	16.26	67.76	13.73	57.22
FEB 5	16.94	70.58	16.48	68.65	14.48	60.35	13.73	57.20
FEB 6	15.88	66.16	15.20	63.35	14.29	59.54	13.73	57.19
FEB 7	14.75	61.44	14.70	61.24	14.24	59.32	13.73	57.19
FEB 8	14.74	61.43	14.69	61.22	14.23	59.31	13.72	57.18
FEB 9	14.74	61.43	14.69	61.22	14.23	59.30	13.72	57.18

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JAN 27	15.90	66.20	13.18	54.93	12.74	53.09	12.52	52.17
JAN 28	13.44	56.00	13.18	54.93	12.74	53.09	12.52	52.17
JAN 29	13.43	55.96	13.18	54.93	12.74	53.09	12.52	52.17
JAN 30	13.41	55.89	13.18	54.92	12.74	53.09	12.52	52.17
JAN 31	13.39	55.81	13.18	54.92	12.74	53.09	12.52	52.17
FEB 1	13.37	55.72	13.18	54.92	12.74	53.09	12.52	52.17
FEB 2	13.35	55.63	13.18	54.91	12.74	53.09	12.52	52.17
FEB 3	13.34	55.57	13.18	54.91	12.74	53.09	12.52	52.16
FEB 4	13.32	55.51	13.18	54.91	12.74	53.09	12.52	52.16
FEB 5	13.32	55.49	13.18	54.90	12.74	53.09	12.52	52.16
FEB 6	13.32	55.48	13.18	54.90	12.74	53.09	12.52	52.15
FEB 7	13.31	55.46	13.17	54.89	12.74	53.08	12.52	52.15
FEB 8	13.31	55.46	13.17	54.89	12.74	53.08	12.52	52.15
FEB 9	13.32	55.46	13.17	54.88	12.74	53.08	12.51	52.14

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
FEB 10	14.74	61.43	14.69	61.22	14.23	59.30	13.72	57.18
FEB 11	14.75	61.44	14.69	61.22	14.23	59.30	13.72	57.18
FEB 12	15.54	64.76	14.90	62.09	14.24	59.35	13.72	57.17
FEB 13	16.40	68.35	15.95	66.45	14.41	60.05	13.72	57.18
FEB 14	17.21	71.70	16.87	70.29	15.59	64.97	13.73	57.21
FEB 15	17.99	74.97	17.71	73.79	16.75	69.77	13.74	57.26
FEB 16	18.90	78.77	18.61	77.56	17.77	74.05	14.33	59.72
FEB 17	19.74	82.25	19.49	81.19	18.79	78.29	16.28	67.82
FEB 18	20.72	86.35	20.46	85.23	19.82	82.59	17.85	74.38
FEB 19	21.71	90.48	21.45	89.37	20.86	86.90	19.22	80.07
FEB 20	22.71	94.61	22.45	93.52	21.89	91.21	20.51	85.48
FEB 21	23.68	98.65	23.43	97.63	22.90	95.42	21.76	90.66
FEB 22	24.00	100.00	24.00	100.00	24.00	100.00	22.88	95.35
FEB 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-0 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-1 HOURS	TIME O/O
FEB 10	13.32	55.49	13.17	54.88	12.74	53.08	12.51	52.14
FEB 11	13.32	55.50	13.17	54.87	12.74	53.08	12.51	52.13
FEB 12	13.32	55.51	13.17	54.87	12.74	53.08	12.51	52.13
FEB 13	13.33	55.52	13.17	54.86	12.74	53.08	12.51	52.12
FEB 14	13.33	55.54	13.16	54.85	12.74	53.08	12.51	52.11
FEB 15	13.33	55.55	13.16	54.84	12.74	53.08	12.50	52.10
FEB 16	13.34	55.57	13.16	54.83	12.74	53.08	12.50	52.09
FEB 17	13.34	55.59	13.16	54.82	12.74	53.07	12.50	52.08
FEB 18	13.35	55.61	13.16	54.81	12.74	53.07	12.49	52.06
FEB 19	13.35	55.64	13.15	54.80	12.75	53.11	12.49	52.04
FEB 20	13.36	55.66	13.15	54.79	12.75	53.14	12.48	52.02
FEB 21	13.36	55.48	13.14	54.77	12.76	53.18	12.48	52.00
FEB 22	13.37	55.71	13.14	54.75	12.77	53.23	12.47	51.97
FEB 23	18.29	76.20	13.13	54.72	12.78	53.27	12.47	51.94

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DAY OF THE YEAR	G[illegible] 1.5x1[illegible] HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
FEB 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.0
FEB 25	24.00	100.00	24.00	100.00	24.00	100.00	23.50	97.9
FEB 26	24.00	100.00	24.00	100.00	23.55	98.11	22.59	94.14
FEB 27	23.49	97.86	23.30	97.08	22.74	94.74	21.65	90.2
FEB 28	22.73	94.72	22.49	93.72	21.92	91.34	20.62	85.9
MAR 1	21.96	91.51	21.69	90.38	21.07	87.81	19.46	81.1
MAR 2	21.13	88.06	20.86	86.93	20.15	83.95	18.14	75.5
MAR 3	20.21	84.22	19.92	83.00	19.12	79.67	16.39	68.3
MAR 4	18.98	79.10	18.71	77.95	17.93	74.70	14.00	58.3
MAR 5	17.99	74.94	17.68	73.68	16.67	69.45	13.79	57.4
MAR 6	16.98	70.74	16.62	69.25	15.20	63.32	13.72	57.1
MAR 7	15.96	66.52	15.46	64.42	14.25	59.37	13.69	56.9
MAR 8	14.95	62.30	14.48	60.32	14.17	59.03	13.6	56.9
MAR 9	14.50	60.40	14.47	60.27	14.15	58.96	13.67	56.9

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
FEB 24	19.50	81.26	13.12	54.68	12.79	53.31	12.46	51.90
FEB 25	18.26	76.10	13.11	54.64	12.80	53.34	12.45	51.87
FEB 26	13.44	56.01	13.11	54.61	12.81	53.38	12.44	51.84
FEB 27	13.44	56.01	13.10	54.57	12.82	53.42	12.44	51.85
FEB 28	13.44	55.99	13.09	54.52	12.83	53.45	12.45	51.85
MAR 1	13.43	55.96	13.07	54.47	12.84	53.49	12.45	51.86
MAR 2	13.43	55.94	13.06	54.42	12.84	53.52	12.45	51.86
MAR 3	13.42	55.92	13.04	54.35	12.85	53.54	12.45	51.87
MAR 4	13.42	55.92	13.03	54.28	12.86	53.56	12.45	51.87
MAR 5	13.42	55.91	13.01	54.20	12.86	53.59	12.45	51.88
MAR 6	13.42	55.91	12.99	54.14	12.86	53.60	12.45	51.88
MAR 7	13.42	55.92	12.99	54.14	12.87	53.62	12.45	51.88
MAR 8	13.42	55.93	12.99	54.14	12.87	53.63	12.45	51.88
MAR 9	13.42	55.93	12.99	54.14	12.87	53.64	12.45	51.88

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
MAR 10	14.50	60.40	14.47	60.27	14.15	58.96	13.67	56.97
MAR 11	14.50	60.40	14.47	60.27	14.15	58.96	13.67	56.97
MAR 12	14.50	60.40	14.46	60.27	14.15	58.96	13.67	56.96
MAR 13	14.86	61.90	14.47	60.30	14.16	58.99	13.67	56.96
MAR 14	15.73	65.53	15.22	63.40	14.22	59.24	13.68	56.98
MAR 15	16.64	69.32	16.23	67.61	14.67	61.14	13.70	57.08
MAR 16	17.49	72.89	17.19	71.64	16.10	67.08	13.75	57.29
MAR 17	18.47	76.96	18.18	75.75	17.33	72.20	13.85	57.73
MAR 18	19.46	81.09	19.18	79.93	18.48	77.01	15.38	64.06
MAR 19	20.46	85.25	20.19	84.14	19.60	81.66	17.36	72.33
MAR 20	21.45	89.36	21.19	88.29	20.67	86.11	18.91	78.78
MAR 21	22.62	94.24	22.37	93.27	21.73	90.53	20.26	84.42
MAR 22	23.48	97.82	23.21	96.70	22.66	94.40	21.47	89.47
MAR 23	24.00	100.00	24.00	100.00	23.55	98.14	22.55	93.94

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
MAR 10	13.42	55.92	12.99	54.14	12.88	53.65	12.45	51.89
MAR 11	13.42	55.92	12.99	54.14	12.88	53.65	12.45	51.89
MAR 12	13.42	55.92	12.99	54.14	12.88	53.65	12.45	51.89
MAR 13	13.42	55.92	12.99	54.14	12.88	53.65	12.45	51.89
MAR 14	13.42	55.92	12.99	54.14	12.87	53.64	12.45	51.88
MAR 15	13.42	55.92	12.99	54.14	12.87	53.63	12.45	51.88
MAR 16	13.42	55.92	12.99	54.14	12.87	53.61	12.45	51.88
MAR 17	13.42	55.92	12.99	54.14	12.86	53.59	12.45	51.88
MAR 18	13.42	55.92	13.00	54.17	12.86	53.57	12.45	51.87
MAR 19	13.42	55.92	13.02	54.25	12.85	53.54	12.45	51.87
MAR 20	13.43	55.94	13.04	54.34	12.84	53.51	12.45	51.86
MAR 21	13.43	55.96	13.06	54.41	12.83	53.47	12.45	51.86
MAR 22	13.43	55.96	13.07	54.47	12.82	53.42	12.44	51.85
MAR 23	13.43	55.96	13.09	54.53	12.81	53.37	12.44	51.84

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
MAR 24	24.00	100.00	24.00	100.00	24.00	100.00	23.52	98.02
MAR 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 27	24.00	100.00	24.00	100.00	24.00	100.00	23.09	96.21
MAR 28	23.90	99.57	23.67	98.64	23.16	96.51	22.14	92.26
MAR 29	23.00	95.82	22.85	95.20	22.29	92.87	21.07	87.78
MAR 30	22.20	92.51	21.94	91.41	21.36	89.01	19.87	82.77
MAR 31	21.23	88.47	20.97	87.38	20.36	84.84	18.50	77.07
APR 1	20.24	84.34	19.98	83.25	19.29	80.36	16.86	70.27
APR 2	19.24	80.18	18.97	79.05	18.17	75.70	14.76	61.51
APR 3	18.27	76.12	17.96	74.84	16.99	70.79	13.76	57.33
APR 4	17.36	72.33	16.98	70.77	15.72	65.49	13.72	57.17
APR 5	16.44	68.50	16.01	66.71	14.43	60.11	13.71	57.15
APR 6	15.51	64.63	14.94	62.25	14.23	59.30	13.71	57.13

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x 10EXP+1	
MAR 24	17.58	73.24	13.10	54.58	12.79	53.31	12.44	51.83
MAR 25	19.58	81.60	13.11	54.63	12.78	53.25	12.45	51.88
MAR 26	19.30	80.41	13.12	54.68	12.76	53.17	12.46	51.93
MAR 27	16.92	70.50	13.13	54.72	12.74	53.10	12.47	51.97
MAR 28	13.33	55.54	13.14	54.75	12.74	53.08	12.48	52.01
MAR 29	13.31	55.48	13.14	54.77	12.74	53.07	12.49	52.04
MAR 30	13.30	55.41	13.15	54.79	12.74	53.07	12.50	52.07
MAR 31	13.28	55.34	13.15	54.80	12.74	53.07	12.50	52.09
APR 1	13.28	55.27	13.15	54.81	12.74	53.07	12.50	52.10
APR 2	13.25	55.20	13.16	54.82	12.74	53.07	12.51	52.11
APR 3	13.25	55.20	13.16	54.83	12.74	53.07	12.51	52.12
APR 4	13.25	55.20	13.16	54.83	12.74	53.07	12.51	52.12
APR 5	13.25	55.20	13.16	54.83	12.74	53.07	12.51	52.12
APR 6	13.25	55.20	13.16	54.83	12.74	53.07	12.51	52.12

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
APR 7	14.74	61.44	14.69	61.20	14.21	59.23	13.71	57.13
APR 8	14.74	61.43	14.69	61.19	14.21	59.22	13.71	57.13
APR 9	14.74	61.43	14.69	61.19	14.21	59.22	13.71	57.13
APR 10	14.94	61.43	14.69	61.19	14.21	59.22	13.71	57.12
APR 11	14.74	61.43	14.69	61.20	14.21	59.22	13.71	57.12
APR 12	15.42	64.25	14.72	61.33	14.23	59.28	13.71	57.12
APR 13	16.41	68.38	15.91	66.30	14.37	59.87	13.71	57.13
APR 14	17.42	72.60	17.04	70.99	15.61	65.06	13.72	57.16
APR 15	18.44	76.82	18.11	75.44	17.02	70.91	13.74	57.24
APR 16	19.44	81.00	19.14	79.75	18.26	76.08	14.25	59.37
APR 17	20.41	85.05	20.13	83.88	19.39	80.80	16.78	69.91
APR 18	21.24	88.52	21.05	87.69	20.42	85.10	18.49	77.05
APR 19	22.17	92.38	21.92	91.34	21.35	88.97	19.80	82.52
APR 20	22.96	95.67	22.71	94.62	22.21	92.52	20.92	87.18

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0
APR 7	13.26	55.23	13.16	54.82	12.74	53.07	12.51	52.11
APR 8	13.28	55.31	13.16	54.82	12.74	53.07	12.51	52.11
APR 9	13.29	55.38	13.15	54.81	12.74	53.07	12.50	52.10
APR 10	13.31	55.44	13.15	54.80	12.74	53.07	12.50	52.08
APR 11	13.32	55.51	13.15	54.79	12.74	53.07	12.50	52.06
APR 12	13.33	55.55	13.15	54.77	12.74	53.07	12.49	52.04
APR 13	13.34	55.60	13.14	54.76	12.74	53.09	12.48	52.02
APR 14	13.35	55.64	13.14	54.74	12.76	53.15	12.48	52.00
APR 15	13.36	55.68	13.13	54.73	12.77	53.21	12.47	51.97
APR 16	13.37	55.72	13.13	54.71	12.78	53.26	12.47	51.94
APR 17	13.38	55.75	13.13	54.69	12.79	53.31	12.46	51.91
APR 18	13.39	55.78	13.12	54.68	12.80	53.35	12.45	51.89
APR 19	13.39	55.81	13.12	54.66	12.81	53.39	12.45	51.86
APR 20	13.40	55.84	13.12	54.65	12.82	53.42	12.44	51.85

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-3 HOURS	TIME 0/0
APR 21	23.72	98.84	23.47	97.80	23.01	95.87	21.95	91.44
APR 22	24.00	100.00	24.00	100.00	24.00	100.00	22.88	95.32
APR 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR 25	24.00	100.00	24.00	100.00	24.00	100.00	23.71	98.79
APR 26	24.00	100.00	24.00	100.00	23.63	98.45	22.63	94.30
APR 27	23.48	97.82	23.21	96.70	22.66	94.43	21.50	89.57
APR 28	22.49	93.70	22.27	92.79	21.66	90.26	20.25	84.38
APR 29	21.49	89.56	21.28	88.67	20.63	85.96	18.91	78.78
APR 30	20.52	85.50	20.29	84.54	19.59	81.62	17.50	72.94
MAY 1	19.62	81.75	19.33	80.55	18.54	77.26	15.88	66.15
MAY 2	18.71	77.94	18.40	76.68	17.51	72.94	14.04	58.48
MAY 3	17.84	74.35	17.52	72.99	16.45	68.54	13.86	57.74
MAY 4	16.98	70.77	16.65	69.38	15.26	63.58	13.80	57.51

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP+1 HOURS	TIME 0/0
APR 21	13.41	55.86	13.11	54.63	12.83	53.45	12.44	51.85
APR 22	15.64	65.15	13.11	54.61	12.84	53.48	12.45	51.86
APR 23	18.79	78.30	13.10	54.59	12.84	53.51	12.45	51.86
APR 24	19.92	82.99	13.10	54.56	12.85	53.53	12.45	51.87
APR 25	18.12	75.51	13.09	54.54	12.85	53.55	12.45	51.87
APR 26	13.45	56.07	13.09	54.53	12.86	53.56	12.45	51.87
APR 27	13.46	56.07	13.08	54.51	12.86	53.58	12.45	51.87
APR 28	13.45	56.05	13.08	54.50	12.86	53.59	12.45	51.88
APR 29	13.45	56.04	13.08	54.49	12.86	53.60	12.45	51.88
APR 30	13.45	56.02	13.08	54.48	12.87	53.61	12.45	51.88
MAY 1	13.44	56.01	13.07	54.48	12.87	53.62	12.45	51.88
MAY 2	13.44	56.00	13.07	54.47	12.87	53.63	12.45	51.88
MAY 3	13.44	55.99	13.07	54.47	12.87	53.63	12.45	51.88
MAY 4	13.44	55.99	13.07	54.47	12.87	53.64	12.45	51.88

Zero deg: Page 25

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
MAY 5	16.19	67,45	15.70	65.41	14.37	59,88	13.77	57,38
MAY 6	15.33	63,88	14.71	61.28	14.30	59,58	13.76	57.35
MAY 7	14.74	61,44	14.70	61.23	14.29	59,52	13.77	57,36
MAY 8	14.74	61,44	14.70	61.23	14.29	59,53	13.77	57,37
MAY 9	14.74	61,44	14.70	61.24	14.29	59,54	13.77	57,38
MAY 10	14.74	61,44	14.70	61.24	14.29	59,55	13.77	57,39
MAY 11	14,94	62,23	14.71	61.27	14.30	59,58	13.78	57.41
MAY 12	16.04	66,82	15.46	64.40	14.35	59,81	13.78	57.43
MAY 13	17.12	71,33	16,69	69.53	14.98	62,43	13.79	57.47
MAY 14	18.14	75,58	17.78	74.09	16.62	69,23	13.81	57,54
MAY 15	19.06	79.42	18,77	78.20	17.92	74.67	13.96	58.19
MAY 16	19.96	83.17	19.69	82.04	19.00	79.19	16.07	66,95
MAY 17	20.74	86,42	20.53	85.52	19.96	83.19	17.87	74,44
MAY 18	21.50	89,98	21.35	88.97	20.82	86,79	19.17	79,88

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP•0		GREATER THAN 1.5x10EXP•1	
MAY 5	13,44	55,99	13.07	54.47	12.87	53,64	12,45	51,88
MAY 6	13,44	55,99	13.08	54,48	12.87	53,65	12.45	51,89
MAY 7	13,44	56,00	13.08	54,49	12.88	53,65	12.45	51,89
MAY 8	13,44	56,00	13,08	54.50	12.88	53,65	12.45	51,89
MAY 9	13,44	56,00	13,08	54.51	12,88	53,65	12,45	51,89
MAY 10	13,44	56,00	13,09	54.52	12,88	53,65	12,45	51,89
MAY 11	13,44	56,01	13,09	54,54	12,88	53,65	12,45	51,89
MAY 12	13,44	56,01	13,09	54,55	12,88	53,65	12,45	51,89
MAY 13	13,44	56,01	13,10	54,57	12,88	53,65	12,45	51,89
MAY 14	13,44	56,01	13,10	54,59	12,88	53,65	12.45	51,89
MAY 15	13,44	56,01	13,11	54,62	12,88	53,65	12,45	51,89
MAY 16	13,44	56,01	13,11	54,64	12,87	53,64	12,45	51,88
MAY 17	13,44	56,02	13,12	54,67	12,87	53,64	12,45	51,88
MAY 18	13,44	56,02	13,13	54,69	12,87	53,63	12,45	51,88

Zero deg: Page 26

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
MAY 19	22.27	92.81	22.13	92.20	21.[illegible]	[illegible]0.17	20.2[illegible]	84.44
~~MAY 20~~	23.0[illegible]	96.08	22.90	95.42	22.45	93.52	21.28	88.65

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
MAY 19	13.44	56.02	13.13	54.72	12.87	53.62	12.45	51.86
~~MAY 20~~	13.44	56.02	13.14	54.74	12.87	53.61	12.45	51.88

TABLE 2

Number of Hours in which Illumination
Exceeds a Given Level

Thirty-Degree Latitude

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
MAY 20	16.99	70.81	16.94	70.60	16.46	68.59	15.75	65.61
MAY 21	16.99	70.81	16.95	70.61	16.48	68.68	15.78	65.74
MAY 22	17.84	74.29	16.97	70.69	16.53	68.86	15.80	65.85
MAY 23	18.94	78.89	18.34	76.40	16.78	69.91	15.83	65.95
MAY 24	19.90	82.92	19.45	81.02	17.83	74.27	15.85	66.06
MAY 25	20.70	86.25	20.34	84.74	19.14	79.76	15.96	66.50
MAY 26	21.41	89.22	21.08	87.83	20.13	83.89	16.36	68.15
MAY 27	21.98	91.60	21.70	90.42	20.93	87.21	18.12	75.48
MAY 28	22.55	93.95	22.31	92.94	21.62	90.10	19.44	81.01
MAY 29	23.12	96.37	22.87	95.28	22.23	92.61	20.42	85.07
MAY 30	23.64	98.60	23.41	97.54	22.82	95.08	21.28	88.68
MAY 31	24.00	100.00	23.96	99.85	23.41	97.55	22.08	92.01
JUN 1	24.00	100.00	24.00	100.00	24.00	100.00	22.87	95.28
JUN 2	24.00	100.00	24.00	100.00	24.00	100.00	23.89	99.53

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
MAY 20	15.33	63.87	14.94	62.25	14.58	60.74	14.15	58.96
MAY 21	15.35	63.96	14.95	62.29	14.61	60.86	14.16	59.02
MAY 22	15.37	64.03	14.96	62.32	14.63	60.95	14.18	59.10
MAY 23	15.39	64.10	14.98	62.44	14.65	61.02	14.21	59.20
MAY 24	15.40	64.16	15.01	62.52	14.66	61.09	14.23	59.29
MAY 25	15.41	64.20	15.04	62.68	14.68	61.15	14.25	59.38
MAY 26	15.42	64.25	15.08	62.82	14.69	61.20	14.27	59.44
MAY 27	15.45	64.38	15.10	62.93	14.70	61.24	14.28	59.51
MAY 28	15.51	64.62	15.13	63.03	14.71	61.28	14.30	59.57
MAY 29	15.56	64.82	15.15	63.11	14.71	61.31	14.31	59.62
MAY 30	15.59	64.96	15.16	63.17	14.72	61.34	14.32	59.66
MAY 31	15.62	65.08	15.17	63.22	14.73	61.36	14.33	59.70
JUN 1	15.64	65.15	15.18	63.27	14.73	61.38	14.34	59.74
JUN 2	15.64	65.16	15.19	63.30	14.74	61.40	14.34	59.77

Thirty deg: Page 1

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=3 HOURS	TIME 0/0
JUN 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 4	24.00	100.00	24.00	100.00	24.00	100.00	23.75	98.97
JUN 5	24.00	100.00	24.00	100.00	23.68	98.67	22.38	93.26
JUN 6	23.49	97.87	23.22	96.77	22.68	94.49	21.20	88.33
JUN 7	22.68	94.50	22.41	93.37	21.79	90.80	20.06	83.57
JUN 8	21.92	91.35	21.65	90.21	21.01	87.54	18.99	79.14
JUN 9	21.47	89.47	21.18	88.26	20.34	84.74	17.92	74.66
JUN 10	20.89	87.06	20.59	85.78	19.66	81.93	16.64	69.35
JUN 11	20.28	84.50	19.97	83.22	18.98	79.09	16.24	67.67
JUN 12	19.73	82.22	19.41	80.88	18.22	75.90	16.19	67.44
JUN 13	19.20	79.98	18.80	78.35	17.26	71.92	16.17	67.36
JUN 14	18.56	77.35	18.05	75.21	16.98	70.75	16.15	67.30
JUN 15	17.87	74.46	17.45	72.71	16.92	70.49	16.15	67.28
JUN 16	17.49	72.89	17.44	72.66	16.90	70.43	16.15	67.27

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=1 HOURS	TIME 0/0
JUN 3	15.64	65.17	15.20	63.33	14.74	61.41	14.36	59.85
JUN 4	15.64	65.17	15.21	63.36	14.74	61.43	14.39	59.96
JUN 5	15.65	65.26	15.21	63.38	14.74	61.44	14.41	60.05
JUN 6	15.66	65.27	15.22	63.40	14.75	61.45	14.43	60.13
JUN 7	15.67	65.30	15.22	63.41	14.75	61.46	14.45	60.19
JUN 8	15.67	65.31	15.22	63.43	14.78	61.57	14.46	60.25
JUN 9	15.68	65.32	15.22	63.43	14.80	61.68	14.47	60.29
JUN 10	15.68	65.33	15.23	63.44	14.83	61.77	14.48	60.33
JUN 11	15.68	65.33	15.23	63.45	14.84	61.85	14.48	60.35
JUN 12	15.68	65.33	15.23	63.45	14.86	61.92	14.49	60.37
JUN 13	15.68	65.33	15.23	63.45	14.88	61.98	14.49	60.38
JUN 14	15.68	65.33	15.23	63.45	14.89	62.03	14.49	60.38
JUN 15	15.68	65.32	15.23	63.48	14.90	62.07	14.49	60.38
JUN 16	15.68	65.32	15.26	63.57	14.90	62.10	14.49	60.37

Thirty deg: Page 2

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
JUN 17	17.49	72.89	17.44	72.66	16.91	70.46	16.14	67.26
JUN 18	17.49	72.89	17.44	72.66	16.91	70.48	16.14	67.24
JUN 19	17.49	72.89	17.44	72.66	16.92	70.50	16.13	67.22
JUN 20	17.50	72.90	17.44	72.67	16.93	70.53	16.13	67.20
JUN 21	18.40	76.66	17.69	73.71	16.97	70.72	16.12	67.18
JUN 22	19.20	79.98	18.72	78.00	17.15	71.46	16.12	67.15
JUN 23	19.86	82.85	19.48	81.17	18.14	75.60	16.17	67.37
JUN 24	20.47	85.27	20.15	83.95	19.12	79.66	16.27	67.77
JUN 25	20.99	87.45	20.71	86.28	19.88	82.84	16.61	69.20
JUN 26	21.53	89.70	21.28	88.66	20.54	85.58	17.89	74.52
JUN 27	22.13	92.21	21.86	91.09	21.17	88.19	19.00	79.15
JUN 28	22.71	94.62	22.43	93.47	21.79	90.81	19.91	82.97
JUN 29	23.34	97.25	23.10	96.26	22.44	93.52	20.79	86.64
JUN 30	24.00	100.00	23.83	99.31	23.18	96.60	21.74	90.59

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN 17	15.67	65.30	15.28	63.65	14.91	62.13	14.49	60.35
JUN 18	15.67	65.29	15.29	63.71	14.92	62.16	14.48	60.33
JUN 19	15.67	65.27	15.30	63.75	14.92	62.18	14.47	60.29
JUN 20	15.66	65.25	15.31	63.80	14.93	62.20	14.46	60.25
JUN 21	15.65	65.22	15.32	63.84	14.93	62.21	14.46	60.23
JUN 22	15.64	65.19	15.33	63.86	14.93	62.22	14.46	60.23
JUN 23	15.64	65.18	15.33	63.88	14.93	62.22	14.46	60.23
JUN 24	15.65	65.22	15.33	63.89	14.93	62.22	14.46	60.23
JUN 25	15.66	65.26	15.33	63.89	14.93	62.22	14.45	60.23
JUN 26	15.67	65.29	15.33	63.88	14.93	62.22	14.45	60.22
JUN 27	15.68	65.32	15.33	63.87	14.93	62.21	14.45	60.21
JUN 28	15.67	65.30	15.32	63.84	14.93	62.20	14.45	60.20
JUN 29	15.66	65.26	15.31	63.80	14.92	62.18	14.45	60.19
JUN 30	15.64	65.17	15.30	63.75	14.92	62.16	14.44	60.17

Thirty deg: Page 3

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
JUL 1	24.00	100.00	24.00	100.00	24.00	100.00	22.73	94.71
JUL 2	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 4	24.00	100.00	24.00	100.00	24.00	100.00	23.00	95.85
JUL 5	24.00	100.00	24.00	100.00	23.43	97.64	22.06	91.92
JUL 6	23.59	98.27	23.36	97.31	22.71	94.63	21.15	88.14
JUL 7	22.97	95.70	22.70	94.56	22.07	91.96	20.27	84.44
JUL 8	22.42	93.42	22.14	92.27	21.45	89.36	19.36	80.69
JUL 9	21.87	91.14	21.59	89.98	20.84	86.84	18.34	76.41
JUL 10	21.31	88.78	21.02	87.57	20.17	84.05	16.89	70.37
JUL 11	20.73	86.40	20.43	85.12	19.42	80.91	16.07	66.94
JUL 12	20.17	84.02	19.78	82.41	18.46	76.90	15.96	66.50
JUL 13	19.45	81.05	18.99	79.12	17.08	71.17	15.92	66.34
JUL 14	18.64	77.67	17.98	74.91	16.74	69.74	15.89	66.20

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
JUL 1	15.63	65.11	15.29	63.69	14.91	62.14	14.44	60.15
JUL 2	15.61	65.02	15.27	63.61	14.91	62.11	14.43	60.13
JUL 3	15.58	64.90	15.25	63.53	14.90	62.08	14.43	60.11
JUL 4	15.56	64.84	15.22	63.43	14.89	62.04	14.42	60.08
JUL 5	15.56	64.83	15.19	63.30	14.88	61.98	14.41	60.05
JUL 6	15.55	64.80	15.16	63.18	14.86	61.93	14.40	60.02
JUL 7	15.55	64.77	15.16	63.17	14.85	61.86	14.39	59.97
JUL 8	15.53	64.73	15.16	63.15	14.83	61.77	14.38	59.93
JUL 9	15.52	64.67	15.15	63.13	14.80	61.67	14.37	59.88
JUL 10	15.50	64.60	15.14	63.10	14.77	61.55	14.36	59.82
JUL 11	15.48	64.51	15.14	63.07	14.74	61.41	14.34	59.75
JUL 12	15.46	64.41	15.13	63.03	14.71	61.29	14.32	59.67
JUL 13	15.44	64.32	15.11	62.98	14.70	61.27	14.30	59.59
JUL 14	15.42	64.26	15.10	62.92	14.70	61.24	14.28	59.48

Thirty deg: Page 4

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-6		GREATER THAN 1.5x 10EXP-5		GREATER THAN 1.5x 10EXP-4		GREATER THAN 1.5x 10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JUL 15	17.64	73.49	17.19	71.64	16.65	69.37	15.86	66.09
JUL 16	17.29	71.85	17.16	71.59	16.63	69.27	15.83	65.98
JUL 17	17.24	71.85	17.18	71.59	16.61	69.20	15.81	65.86
JUL 18	17.24	71.85	17.18	71.58	16.59	69.12	15.77	65.71
JUL 19	17.24	71.84	17.18	71.57	16.57	69.02	15.73	65.55
JUL 20	17.32	72.17	17.18	71.59	16.56	68.99	15.73	65.53
JUL 21	18.00	74.98	17.47	72.80	16.62	69.23	15.72	65.51
JUL 22	18.66	77.76	18.24	76.01	16.64	69.34	15.72	65.49
JUL 23	19.21	80.03	18.87	78.61	17.61	73.38	15.72	65.50
JUL 24	19.73	82.22	19.43	80.96	18.38	76.59	15.74	65.59
JUL 25	20.09	83.73	19.81	82.52	19.05	79.36	16.01	66.71
JUL 26	20.72	86.31	20.44	85.15	19.75	82.29	17.17	71.53
JUL 27	21.43	89.29	21.15	88.11	20.48	85.33	18.32	76.33
JUL 28	22.21	92.53	21.93	91.38	21.30	88.76	19.48	81.17

	GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x 10EXP+1	
JUL 15	15.41	64,19	15,09	62.86	14,69	61,22	14,25	59,37
JUL 16	15.39	64,11	15,07	62.78	14,68	61,19	14,22	59,23
JUL 17	15.36	64,02	15,05	62.69	14,68	61,15	14,21	59,19
JUL 18	15,34	63,91	15,02	62.58	14,67	61,11	14,20	59,16
JUL 19	15,31	63,78	14,99	62.46	14,66	61,07	14,19	59,12
JUL 20	15,27	63,62	14,95	62.31	14,64	61,01	14,18	59,08
JUL 21	15,24	63,49	14,91	62,12	14,63	60,95	14,17	59,03
JUL 22	15,23	63,47	14,86	61,94	14,61	60,87	14,16	58,98
JUL 23	15,23	63,45	14,84	61,82	14,59	60,79	14,14	58,93
JUL 24	15,22	63,43	14,80	61,67	14,57	60,69	14,13	58,87
JUL 25	15,22	63,40	14,76	61.49	14,54	60,58	14,11	58,81
JUL 26	15,21	63,37	14,74	61.43	14,50	60,43	14,10	58,73
JUL 27	15,20	63,35	14,74	61.41	14,46	60,26	14,08	58,65
JUL 28	15,19	63,29	14,73	61,39	14,42	60,06	14,05	58,56

Thirty deg: Page 5

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
JUL 29	23.08	96.18	22.84	95.16	22.21	92.55	20.68	86.18
~~JUL 30~~	24.00	100.00	23.82	99.27	23.22	96.74	21.92	91.35
JUL 31	24.00	100.00	24.00	100.00	24.00	100.00	23.18	96.59
~~AUG~~ 1	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 2	24.00	100.00	24.00	100.00	24.00	100.00	23.75	98.97
AUG 3	24.00	100.00	24.00	100.00	24.00	100.00	22.79	94.96
AUG 4	24.00	100.00	23.98	99.91	23.37	97.37	22.01	91.71
AUG 5	23.70	98.74	23.42	97.60	22.78	94.93	21.23	88.46
AUG 6	23.17	96.56	22.90	95.41	22.19	92.45	20.41	85.03
AUG 7	22.64	94.31	22.35	93.13	21.56	89.85	19.46	81.07
AUG 8	21.75	90.61	21.49	89.53	20.80	86.66	18.17	75.70
AUG 9	21.18	88.27	20.86	86.93	19.98	83.27	16.30	67.92
AUG 10	20.45	85.22	20.10	83.76	18.99	79.14	15.34	63.92
AUG 11	19.62	81.74	19.18	79.91	17.66	73.60	15.20	63.34

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0
JUL 29	15.18	63.23	14.73	61.36	14.36	59.82	14.03	58.46
~~JUL 30~~	15.16	63.16	14.72	61.34	14.30	59.58	14.00	58.33
JUL 31	15.13	63.06	14.71	61.30	14.26	59.41	13.97	58.20
~~AUG 1~~	15.11	62.96	14.70	61.26	14.24	59.34	13.93	58.04
AUG 2	15.09	62.86	14.69	61.21	14.24	59.32	13.89	57.86
~~AUG 3~~	15.06	62.76	14.67	61.15	14.23	59.29	13.83	57.64
AUG 4	15.03	62.61	14.66	61.07	14.22	59.26	13.78	57.42
~~AUG 5~~	14.97	62.39	14.63	60.98	14.21	59.23	13.74	57.27
AUG 6	14.90	62.08	14.61	60.86	14.21	59.19	13.73	57.23
~~AUG 7~~	14.84	61.84	14.57	60.72	14.19	59.14	13.72	57.18
AUG 8	14.78	61.59	14.53	60.54	14.18	59.09	13.71	57.13
~~AUG 9~~	14.74	61.43	14.48	60.32	14.16	59.02	13.70	57.08
AUG 10	14.74	61.40	14.41	60.05	14.15	58.94	13.69	57.03
~~AUG 11~~	14.73	61.37	14.33	59.71	14.12	58.84	13.67	56.97

Thirty deg: Page 6

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
AUG 12	18.64	77.66	18.08	75.32	15.96	66.51	15.17	63.22
AUG 13	17.50	72.92	16.71	69.62	15.79	65.78	15.15	63.11
AUG 14	16.25	67.73	16.20	67.48	15.72	65.51	15.12	62.99
AUG 15	16.24	67.68	16.19	67.45	15.70	65.43	15.08	62.84
AUG 16	16.24	67.68	16.19	67.44	15.68	65.35	15.04	62.67
AUG 17	16.24	67.68	16.18	67.43	15.66	65.26	14.99	62.47
AUG 18	16.24	67.68	16.18	67.42	15.64	65.17	14.93	62.22
AUG 19	16.48	68.65	16.19	67.47	15.63	65.14	14.87	61.98
AUG 20	17.11	71.29	16.63	69.29	15.69	65.37	14.85	61.87
AUG 21	17.70	73.75	17.32	72.16	15.84	66.00	14.82	61.76
AUG 22	18.31	76.29	17.95	74.80	16.83	70.11	14.79	61.64
AUG 23	18.98	79.07	18.66	77.76	17.67	73.64	14.82	61.77
AUG 24	19.73	82.20	19.43	80.94	18.54	77.25	15.05	62.72
AUG 25	20.62	85.93	20.31	84.61	19.48	81.15	16.69	69.53

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
AUG 12	14.72	61.32	14.29	59.55	14.09	58.72	13.66	56.90
AUG 13	14.71	61.27	14.25	59.36	14.06	58.58	13.64	56.82
AUG 14	14.69	61.21	14.24	59.34	14.01	58.39	13.62	56.74
AUG 15	14.67	61.13	14.24	59.31	13.96	58.17	13.59	56.64
AUG 16	14.65	61.04	14.23	59.28	13.89	57.89	13.57	56.53
AUG 17	14.62	60.92	14.22	59.25	13.85	57.71	13.53	56.39
AUG 18	14.59	60.77	14.21	59.20	13.82	57.58	13.50	56.24
AUG 19	14.54	60.60	14.19	59.14	13.78	57.44	13.45	56.05
AUG 20	14.49	60.38	14.18	59.07	13.74	57.26	13.40	55.82
AUG 21	14.42	60.10	14.15	58.97	13.73	57.20	13.36	55.69
AUG 22	14.39	59.97	14.12	58.85	13.72	57.16	13.34	55.59
AUG 23	14.37	59.88	14.09	58.69	13.71	57.11	13.32	55.48
AUG 24	14.34	59.76	14.04	58.49	13.69	57.05	13.28	55.35
AUG 25	14.31	59.64	13.97	58.22	13.67	56.96	13.25	55.21

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6		GREATER THAN 1.5x10EXP=5		GREATER THAN 1.5x 10EXP=4		GREATER THAN 1.5x 10EXP=3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
AUG 26	21.27	88.63	21.02	87.60	20.43	85.11	18.27	76.14
~~AUG 27~~	22.33	93.02	22.08	92.01	21.49	89.56	19.79	82.48
AUG 28	23.42	97.59	23.16	96.52	22.61	94.22	21.26	88.57
~~AUG 29~~	24.00	100.00	24.00	100.00	23.76	99.00	22.60	94.18
AUG 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~AUG 31~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 1	24.00	100.00	24.00	100.00	24.00	100.00	23.33	97.21
~~SEP 2~~	24.00	100.00	24.00	100.00	23.84	99.34	22.65	94.38
SEP 3	23.96	99.82	23.70	98.75	23.19	96.63	21.90	91.26
~~SEP 4~~	23.42	97.58	23.16	96.49	22.57	94.03	21.05	87.69
SEP 5	22.75	94.78	22.52	93.84	21.88	91.18	20.03	83.47
~~SEP 6~~	22.16	92.33	21.85	91.06	21.11	87.96	18.80	78.32
SEP 7	21.39	89.12	21.04	87.69	20.18	84.07	17.05	71.03
~~SEP 8~~	20.47	85.30	20.13	83.87	19.07	79.47	14.69	61.22

	GREATER THAN 1.5x10EXP=2		GREATER THAN 1.5x 10EXP=1		GREATER THAN 1.5x 10EXP=0		GREATCH THAN 1.5x 10EXP=1	
AUG 26	14.28	59.49	13.94	58.08	13.65	56.88	13.21	55.05
~~AUG 27~~	14.23	59.30	13.92	58.02	13.62	56.76	13.19	54.95
AUG 28	14.22	59.24	13.91	57.94	13.58	56.60	13.17	54.87
~~AUG 29~~	14.20	59.18	13.89	57.86	13.53	56.39	13.15	54.78
AUG 30	14.18	59.08	13.86	57.75	13.47	56.12	13.12	54.68
~~AUG 31~~	16.98	70.77	13.83	57.63	13.46	56.07	13.09	54.55
SEP 1	14.10	58.76	13.80	57.49	13.45	56.03	13.05	54.39
~~SEP 2~~	14.05	58.55	13.75	57.31	13.43	55.98	13.01	54.20
SEP 3	14.00	58.32	13.70	57.08	13.42	55.92	12.96	54.01
~~SEP 4~~	13.99	58.29	13.65	56.87	13.40	55.84	12.95	53.96
SEP 5	13.98	58.25	13.61	56.70	13.38	55.75	12.94	53.90
~~SEP 6~~	13.97	58.20	13.56	56.49	13.35	55.64	12.92	53.84
SEP 7	13.95	58.14	13.49	56.23	13.32	55.50	12.90	53.77
~~SEP 8~~	13.93	58.09	13.49	56.21	13.28	55.33	12.88	53.69

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
SEP 9	19.47	81.13	19.08	79.51	17.72	73.81	14.35	59.79
SEP 10	18.40	76.66	17.91	74.63	16.01	66.71	14.26	59.41
SEP 11	17.21	71.72	16.59	69.12	14.97	62.39	14.17	59.05
SEP 12	15.99	66.62	15.44	64.33	14.83	61.79	14.08	58.68
SEP 13	15.24	63.52	15.19	63.30	14.72	61.34	14.03	58.46
SEP 14	15.[illegible]	62.48	14.96	62.35	14.63	60.96	14.00	58.32
SEP 15	15.0[illegible]	62.48	14.96	62.33	14.60	60.82	13.99	58.28
SEP 16	15.0[illegible]	62.48	14.96	62.32	14.56	60.68	13.98	58.24
SEP 17	15.0[illegible]	62.49	14.95	62.31	14.55	60.61	13.97	58.20
SEP 18	15.4[illegible]	64.99	15.01	62.55	14.54	60.60	13.95	58.14
SEP 19	16.2[illegible]	67.74	15.86	66.08	14.65	61.05	13.94	58.09
SEP 20	17.0[illegible]	70.82	16.66	69.40	15.30	63.76	13.93	58.05
SEP 21	17.8[illegible]	74.52	17.51	72.97	16.45	68.56	13.94	58.07
SEP 22	18.7[illegible]	78.10	18.46	76.90	17.58	73.23	13.97	58.19

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP 0		GREATER THAN 1.5x10EXP+1	
SEP [illegible]	13.91	57.97	13.48	56.19	13.23	55.12	12.86	53.60
SEP [illegible]	13.88	57.85	13.48	56.16	13.16	54.84	12.84	53.49
SEP 11	13.85	57.72	13.47	56.12	13.08	54.49	12.81	53.37
SEP 12	13.81	57.54	13.46	56.08	13.01	54.21	12.77	53.22
SEP 13	13.76	57.33	13.44	56.02	12.99	54.14	12.73	53.04
SEP 14	13.69	57.06	13.43	55.94	12.99	54.11	12.68	52.82
SEP 15	13.62	56.74	13.40	55.84	12.98	54.08	12.61	52.55
SEP 16	13.59	56.64	13.37	55.70	12.97	54.04	12.58	52.43
SEP 17	13.57	56.54	13.32	55.51	12.96	53.99	12.56	52.31
SEP 18	13.54	56.40	13.27	55.27	12.94	53.93	12.53	52.19
SEP 19	13.50	56.24	13.19	54.95	12.92	53.85	12.49	52.05
SEP 20	13.47	56.14	13.18	54.90	12.90	53.74	12.45	51.90
SEP 21	13.46	56.09	13.16	54.84	12.87	53.61	12.44	51.83
SEP 22	13.45	56.03	13.14	54.76	12.82	53.43	12.42	51.74

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x 10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
SEP 23	19.78	82.40	19.47	81.14	18.73	78.03	15.36	64.01
~~SEP 24~~	20.88	87.01	20.59	85.80	19.89	82.87	17.57	73.22
SEP 25	21.95	91.47	21.68	90.31	21.05	87.70	19.30	80.43
~~SEP 26~~	22.98	95.76	22.72	94.65	22.17	92.37	20.80	86.68
SEP 27	23.99	99.98	23.81	99.20	23.23	96.80	22.13	92.20
SEP 28	24.00	100.00	24.00	100.00	24.00	100.00	23.35	97.28
SEP 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 1	24.00	100.00	24.00	100.00	24.00	100.00	23.19	96.63
OCT 2	24.00	100.00	24.00	100.00	23.60	98.33	22.39	93.30
OCT 3	23.74	98.92	23.48	97.85	22.88	95.35	21.43	89.30
OCT 4	23.04	95.95	22.77	94.85	22.08	92.01	20.31	84.63
OCT 5	22.22	92.60	21.92	91.34	21.15	88.12	18.97	79.05
~~OCT 6~~	21.25	88.52	20.94	87.26	20.07	83.62	17.27	71.96

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
SEP 23	13.43	55.96	13.12	54.67	12.76	53.19	12.40	51.65
~~SEP 24~~	13.41	55.87	13.09	54.56	12.72	52.98	12.37	51.53
SEP 25	13.38	55.76	13.06	54.43	12.71	52.94	12.33	51.39
~~SEP 26~~	13.35	55.62	13.03	54.27	12.70	52.90	12.29	51.22
SEP 27	13.30	55.41	12.98	54.07	12.68	52.84	12.24	51.00
~~SEP 28~~	13.23	55.14	12.92	53.83	12.67	52.78	12.21	50.89
SEP 29	18.26	76.08	12.88	53.65	12.65	52.71	12.20	50.83
~~SEP 30~~	18.05	75.20	12.83	53.46	12.63	52.62	12.19	50.77
OCT 1	14.94	62.28	12.77	53.20	12.60	52.50	12.17	50.71
~~OCT 2~~	13.21	55.06	12.74	53.10	12.57	52.37	12.15	50.64
OCT 3	13.20	54.99	12.74	53.08	12.53	52.20	12.13	50.56
~~OCT 4~~	13.18	54.90	12.73	53.06	12.48	51.99	12.11	50.47
OCT 5	13.15	54.79	12.73	53.03	12.41	51.71	12.09	50.36
~~OCT 6~~	13.11	54.64	12.72	53.00	12.33	51.36	12.06	50.24

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
OCT 7	19.98	83.26	19.67	81.98	18.80	78.35	15.01	62.53
OCT 8	18.92	78.83	18.55	77.28	17.48	72.84	13.47	56.12
OCT 9	17.74	73.93	17.38	72.40	15.95	66.45	13.35	55.63
OCT 10	16.65	69.40	16.15	67.28	14.01	58.39	13.26	55.25
OCT 11	15.49	64.54	14.79	61.64	13.86	57.75	13.23	55.13
OCT 12	14.31	59.63	14.21	59.19	13.80	57.50	13.22	55.09
OCT 13	14.25	59.35	14.20	59.17	13.78	57.42	13.21	55.04
OCT 14	14.24	59.35	14.20	59.16	13.76	57.35	13.20	54.98
OCT 15	14.24	59.35	14.19	59.14	13.74	57.27	13.18	54.91
OCT 16	14.24	59.35	14.19	59.13	13.72	57.19	13.16	54.83
OCT 17	14.45	60.21	14.20	59.16	13.71	57.14	13.13	54.73
OCT 18	15.30	63.75	14.75	61.48	13.75	57.29	13.11	54.63
OCT 19	16.23	67.61	15.81	65.90	14.06	58.58	13.10	54.57
OCT 20	17.23	71.80	16.88	70.35	15.63	65.12	13.11	54.61

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
OCT 7	13.07	54.45	12.71	52.95	12.28	51.17	12.02	50.10
OCT 8	13.02	54.24	12.70	52.90	12.24	51.01	11.98	49.93
OCT 9	12.95	53.97	12.68	52.83	12.24	50.99	11.93	49.71
OCT 10	12.88	53.67	12.66	52.73	12.23	50.96	11.87	49.46
OCT 11	12.86	53.57	12.63	52.61	12.22	50.92	11.84	49.34
OCT 12	12.83	53.48	12.59	52.46	12.21	50.88	11.82	49.23
OCT 13	12.81	53.36	12.54	52.27	12.20	50.83	11.79	49.11
OCT 14	12.77	53.22	12.49	52.03	12.16	50.76	11.75	48.97
OCT 15	12.73	53.06	12.43	51.81	12.17	50.69	11.72	48.82
OCT 16	12.72	53.01	12.42	51.75	12.14	50.59	11.70	48.74
OCT 17	12.71	52.96	12.40	51.68	12.11	50.47	11.68	48.68
OCT 18	12.70	52.91	12.38	51.60	12.08	50.32	11.66	48.60
OCT 19	12.68	52.84	12.36	51.50	12.03	50.13	11.64	48.52
OCT 20	12.66	52.77	12.33	51.39	11.98	49.90	11.62	48.42

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
OCT 21	18.30	76.26	17.96	74.82	16.98	70.76	13.15	54.81
~~OCT 22~~	19.42	80.92	19.10	79.59	18.27	76.12	14.26	59.40
OCT 23	20.47	85.30	20.19	84.11	19.49	81.19	17.12	71.32
~~OCT 24~~	21.49	89.54	21.24	88.51	20.63	85.94	18.83	78.46
OCT 25	22.50	93.73	22.31	92.98	21.70	90.41	20.27	84.46
~~OCT 26~~	23.53	98.04	23.35	97.29	22.76	94.84	21.57	89.89
OCT 27	24.00	100.00	24.00	100.00	23.97	99.89	22.76	94.85
~~OCT 28~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~OCT 30~~	24.00	100.00	24.00	100.00	24.00	100.00	23.73	98.86
OCT 31	24.00	100.00	24.00	100.00	24.00	100.00	22.76	94.83
~~NOV 1~~	23.96	99.82	23.68	98.65	23.07	96.11	21.69	90.39
NOV 2	23.01	95.85	22.74	94.76	22.10	92.10	20.46	85.24
~~NOV 3~~	22.01	91.71	21.72	90.50	21.03	87.64	19.06	79.40

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP-0		GREATER THAN 1.5x10EXP+1	
OCT 21	12.34	52.68	12.30	51.26	11.95	49.80	11.60	48.31
~~OCT 22~~	12.62	52.59	12.27	51.11	11.94	49.75	11.57	48.19
OCT 23	12.60	52.50	12.22	50.92	11.93	49.70	11.53	48.04
~~OCT 24~~	12.57	52.39	12.20	50.82	11.91	49.64	11.49	47.87
OCT 25	12.54	52.26	12.18	50.76	11.90	49.56	11.45	47.70
~~OCT 26~~	12.51	52.11	12.16	50.68	11.88	49.48	11.44	47.65
OCT 27	12.46	51.93	12.14	50.58	11.85	49.39	11.42	47.59
~~OCT 28~~	17.84	74.32	12.11	50.46	11.83	49.27	11.41	47.53
OCT 29	19.19	79.96	12.08	50.32	11.79	49.14	11.39	47.46
~~OCT 30~~	17.56	73.17	12.03	50.14	11.76	48.98	11.37	47.38
OCT 31	12.45	51.89	11.99	49.95	11.71	48.80	11.35	47.30
~~NOV 1~~	12.44	51.84	11.98	49.92	11.67	48.62	11.33	47.20
NOV 2	12.42	51.75	11.97	49.89	11.65	48.54	11.30	47.10
~~NOV 3~~	12.39	51.64	11.97	49.86	11.63	48.45	11.28	46.99

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
NOV 4	20.97	87.38	20.67	86.12	19.89	82.87	17.51	72.96
NOV 5	19.89	82.89	19.56	81.48	18.67	77.81	15.59	64.96
NOV 6	18.74	78.08	18.43	76.78	17.41	72.55	13.03	54.29
NOV 7	17.70	73.73	17.33	72.21	16.05	66.88	12.68	52.82
NOV 8	16.63	69.31	16.19	67.45	14.42	60.10	12.57	52.38
NOV 9	15.50	64.58	14.94	62.24	13.30	55.43	12.54	52.26
NOV 10	14.39	59.96	13.70	57.09	13.19	54.94	12.51	52.14
NOV 11	13.74	57.26	13.68	57.02	13.15	54.77	12.49	52.02
NOV 12	13.50	56.23	13.46	56.07	13.08	54.49	12.47	51.97
NOV 13	13.50	56.23	13.46	56.06	13.07	54.44	12.47	51.94
NOV 14	13.50	56.23	13.45	56.06	13.06	54.40	12.46	51.91
NOV 15	13.50	56.24	13.45	56.06	13.05	54.37	12.45	51.87
NOV 16	14.60	60.84	13.90	57.91	13.08	54.48	12.44	51.84
NOV 17	15.70	65.42	15.21	63.36	13.19	54.98	12.43	51.80

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
NOV 4	12.36	51.50	11.96	49.83	11.60	48.35	11.25	46.86
NOV 5	12.32	51.34	11.95	49.78	11.56	48.23	11.21	46.71
NOV 6	12.28	51.16	11.94	49.73	11.54	48.10	11.17	46.54
NOV 7	12.23	50.96	11.92	49.68	11.51	47.95	11.14	46.40
NOV 8	12.18	50.75	11.91	49.61	11.48	47.83	11.12	46.32
NOV 9	12.15	50.64	11.89	49.53	11.47	47.80	11.10	46.24
NOV 10	12.14	50.58	11.87	49.44	11.46	47.77	11.08	46.16
NOV 11	12.12	50.51	11.84	49.34	11.46	47.73	11.05	46.06
NOV 12	12.10	50.44	11.81	49.22	11.45	47.69	11.03	45.95
NOV 13	12.09	50.36	11.78	49.08	11.44	47.65	11.00	45.85
NOV 14	12.07	50.28	11.74	48.92	11.42	47.60	10.98	45.73
NOV 15	12.04	50.18	11.70	48.74	11.41	47.54	10.95	45.64
NOV 16	12.02	50.09	11.68	48.68	11.39	47.48	10.94	45.59
NOV 17	12.00	49.99	11.68	48.65	11.38	47.41	10.93	45.54

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
NOV 18	16.81	70.04	16.42	68.40	14.96	62.34	12.42	51.77
~~NOV 19~~	17.94	74.74	17.59	73.30	16.32	68.00	12.51	52.12
NOV 20	18.98	79.08	18.68	77.85	17.83	74.30	13.49	56.21
~~NOV 21~~	20.00	83.31	19.75	82.27	19.02	79.26	16.53	68.86
NOV 22	21.04	87.65	20.80	86.69	20.12	83.84	18.20	75.84
NOV 23	22.07	91.95	21.84	91.00	21.18	88.24	19.61	81.70
NOV 24	23.12	96.33	22.87	95.31	22.24	92.68	20.89	87.05
NOV 25	24.00	100.00	23.93	99.69	23.31	97.13	22.11	92.11
NOV 26	24.00	100.00	24.00	100.00	24.00	100.00	23.31	97.13
~~NOV 27~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
NOV 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~NOV 29~~	24.00	100.00	24.00	100.00	24.00	100.00	23.13	96.37
NOV 30	24.00	100.00	23.82	99.24	23.22	96.74	21.96	91.49
~~DEC 1~~	22.99	95.79	22.72	94.67	22.14	92.27	20.66	86.06

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP 0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
NOV 18	11.98	49.90	11.67	48.61	11.36	47.32	10.92	45.49
~~NOV 19~~	11.96	49.85	11.66	48.57	11.33	47.23	10.91	45.44
NOV 20	11.96	49.81	11.65	48.53	11.31	47.12	10.89	45.38
~~NOV 21~~	11.95	49.78	11.64	48.48	11.28	46.99	10.88	45.32
NOV 22	11.94	49.74	11.63	48.44	11.24	46.85	10.86	45.25
~~NOV 23~~	11.93	49.72	11.62	48.40	11.21	46.72	10.84	45.18
NOV 24	11.93	49.70	11.60	48.35	11.21	46.70	10.82	45.10
~~NOV 25~~	11.92	49.66	11.59	48.30	11.20	46.68	10.80	45.01
NOV 26	16.77	69.86	11.58	48.25	11.20	46.66	10.78	44.91
~~NOV 27~~	19.05	79.38	11.57	48.20	11.19	46.64	10.75	44.81
NOV 28	18.50	77.07	11.55	48.14	11.19	46.62	10.73	44.69
~~NOV 29~~	15.63	65.11	11.54	48.08	11.18	46.59	10.71	44.64
NOV 30	11.90	49.58	11.53	48.03	11.18	46.57	10.71	44.62
~~DEC 1~~	11.87	49.47	11.51	47.97	11.17	46.55	10.70	44.59

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DAY OF THE YEAR		GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
		HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
DEC	2	21.95	91.45	21.66	90.26	21.01	87.54	19.28	80.35
DEC	3	20.83	86.79	20.55	85.64	19.87	82.80	17.83	74.31
DEC	4	19.73	82.21	19.45	81.04	18.71	77.96	16.15	67.30
DEC	5	18.71	77.94	18.40	76.68	17.54	73.08	13.87	57.78
DEC	6	17.69	73.65	17.34	72.27	16.30	67.93	12.33	51.38
DEC	7	16.63	69.28	16.22	67.60	14.82	61.75	12.21	50.89
DEC	8	15.50	64.59	13.04	62.68	12.98	54.06	12.20	50.84
DEC	9	14.41	60.03	13.64	56.84	12.80	53.33	12.19	50.80
DEC	10	13.25	55.19	13.20	55.00	12.76	53.16	12.19	50.78
DEC	11	13.24	55.19	13.20	54.99	12.76	53.15	12.18	50.76
DEC	12	13.24	55.19	13.20	54.99	12.76	53.15	12.18	50.73
DEC	13	13.24	55.19	13.20	54.99	12.76	53.16	12.17	50.71
DEC	14	13.24	55.19	13.20	54.99	12.76	53.16	12.14	50.69
DEC	15	14.1[illegible]	58.76	13.22	55.08	12.79	53.27	12.16	50.66

DAY OF THE YEAR		GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
DEC	2	11.83	49.31	11.50	47.91	11.17	46.53	10.70	44.57
DEC	3	11.76	49.10	11.48	47.84	11.16	46.51	10.69	44.55
DEC	4	11.74	48.93	11.47	47.77	11.16	46.48	10.69	44.53
DEC	5	11.74	48.92	11.45	47.70	11.15	46.46	10.68	44.51
DEC	6	11.74	48.91	11.43	47.62	11.14	46.43	10.68	44.49
DEC	7	11.74	48.90	11.41	47.54	11.14	46.41	10.67	44.47
DEC	8	11.73	48.89	11.39	47.44	11.13	46.38	10.67	44.45
DEC	9	11.73	48.88	11.36	47.34	11.12	46.34	10.66	44.43
DEC	10	11.73	48.87	11.35	47.31	11.11	46.31	10.66	44.41
DEC	11	11.73	48.86	11.36	47.32	11.11	46.27	10.65	44.39
DEC	12	11.72	48.84	11.36	47.34	11.10	46.23	10.65	44.37
DEC	13	11.72	48.83	11.37	47.37	11.09	46.19	10.64	44.35
DEC	14	11.72	48.82	11.37	47.39	11.08	46.15	10.64	44.32
DEC	15	11.71	48.80	11.36	47.41	11.06	46.09	10.63	44.30

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
DEC 16	15.25	63.54	14.72	61.35	12.89	53.71	12.16	50.65
~~DEC 17~~	16.43	68.45	16.01	66.71	14.41	60.04	12.15	50.64
DEC 18	17.48	72.84	17.16	71.50	16.03	66.81	12.24	51.00
~~DEC 19~~	18.50	77.08	18.21	75.88	17.33	72.20	12.65	52.73
DEC 20	19.56	81.48	19.28	80.33	18.50	77.09	15.78	65.73
~~DEC 21~~	20.60	85.85	20.33	84.72	19.62	81.76	17.55	73.14
DEC 22	21.66	90.25	21.38	89.09	20.70	86.25	18.97	79.05
~~DEC 23~~	22.71	94.63	22.43	93.47	21.81	90.89	20.30	84.58
DEC 24	23.75	98.94	23.53	98.05	22.91	95.45	21.60	90.01
~~DEC 25~~	24.00	100.00	24.00	100.00	24.00	100.00	22.85	95.22
DEC 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~DEC 27~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
DEC 28	24.00	100.00	24.00	100.00	24.00	100.00	23.73	98.89
~~DEC 29~~	24.00	100.00	24.00	100.00	23.61	98.36	22.35	93.13

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP-0		GREATER THAN 1.5x 10EXP+1	
DEC 16	11.71	48.79	11.39	47.44	11.05	46.04	10.63	44.28
~~DEC 17~~	11.70	48.77	11.39	47.47	11.04	45.99	10.62	44.26
DEC 18	11.71	48.78	11.40	47.49	11.02	45.93	10.62	44.24
~~DEC 19~~	11.73	48.88	11.40	47.51	11.01	45.87	10.61	44.22
DEC 20	11.76	48.99	11.41	47.54	10.99	45.81	10.61	44.19
~~DEC 21~~	11.79	49.11	11.42	47.56	10.98	45.75	10.60	44.17
DEC 22	11.81	49.20	11.42	47.58	10.98	45.74	10.60	44.16
~~DEC 23~~	11.83	49.29	11.42	47.60	10.98	45.75	10.59	44.14
DEC 24	11.84	49.34	11.43	47.62	10.98	45.76	10.59	44.12
~~DEC 25~~	14.96	62.32	11.43	47.64	10.98	45.76	10.59	44.13
DEC 26	18.26	76.09	11.44	47.65	10.98	45.77	10.60	44.18
~~DEC 27~~	19.15	79.81	11.44	47.66	10.99	45.77	10.62	44.23
DEC 28	17.30	72.10	11.44	47.67	10.99	45.78	10.63	44.27
~~DEC 29~~	11.66	49.42	11.44	47.69	10.99	45.78	10.64	44.32

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
DEC 30	23.39	97.47	23.12	96.35	22.47	93.63	21.09	87.87
DEC 31	22.24	92.67	22.00	91.66	21.37	89.04	19.78	82.43
JAN 1	21.22	88.42	20.94	87.25	20.28	84.50	18.41	76.73
JAN 2	20.20	84.19	19.92	82.99	19.19	79.96	16.93	70.53
JAN 3	19.19	79.95	18.89	78.70	18.07	75.28	14.90	62.09
JAN 4	18.16	75.67	17.83	74.29	16.85	70.20	12.40	51.68
JAN 5	17.09	71.21	16.71	69.61	15.44	64.33	12.30	51.27
JAN 6	15.97	66.55	15.55	64.79	13.60	56.68	12.25	51.06
JAN 7	14.82	61.76	14.18	59.08	12.97	54.06	12.23	50.98
JAN 8	13.60	56.68	13.44	55.99	12.91	53.78	12.23	50.98
JAN 9	13.49	56.22	13.43	55.97	12.90	53.76	12.24	51.01
JAN 10	13.49	56.22	13.43	55.97	12.91	53.78	12.25	51.05
JAN 11	13.49	56.22	13.43	55.98	12.91	53.80	12.26	51.10
JAN 12	13.49	56.22	13.44	55.98	12.92	53.82	12.27	51.14

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
DEC 30	11.85	49.43	11.45	47.70	10.99	45.79	10.65	44.37
DEC 31	11.86	49.43	11.45	47.70	10.99	45.80	10.66	44.41
JAN 1	11.86	49.42	11.45	47.71	11.00	45.85	10.67	44.45
JAN 2	11.86	49.40	11.45	47.72	11.03	45.97	10.68	44.49
JAN 3	11.85	49.39	11.45	47.73	11.06	46.07	10.69	44.54
JAN 4	11.85	49.38	11.46	47.73	11.08	46.16	10.70	44.58
JAN 5	11.85	49.38	11.46	47.74	11.10	46.25	10.71	44.62
JAN 6	11.85	49.39	11.46	47.75	11.12	46.33	10.72	44.67
JAN 7	11.86	49.41	11.46	47.76	11.13	46.39	10.73	44.71
JAN 8	11.86	49.43	11.46	47.77	11.15	46.45	10.74	44.76
JAN 9	11.87	49.46	11.47	47.78	11.16	46.51	10.75	44.81
JAN 10	11.88	49.48	11.50	47.91	11.17	46.55	10.77	44.85
JAN 11	11.88	49.51	11.53	48.05	11.18	46.60	10.78	44.91
JAN 12	11.89	49.53	11.56	48.17	11.19	46.64	10.79	44.96

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JAN 13	13.90	57.91	13.45	56.02	12.94	53.93	12.29	51.19
~~JAN 14~~	15.11	62.97	14.48	60.32	13.03	54.3[illegible]	12.30	51.25
JAN 15	16.21	67.54	15.77	65.72	13.83	57.6[illegible]	12.31	51.31
~~JAN 16~~	17.24	71.83	16.91	70.44	15.61	65.04	12.36	51.51
JAN 17	18.30	76.26	17.96	74.85	16.98	70.75	12.58	52.43
JAN 18	19.37	80.72	19.06	79.40	18.19	75.78	15.04	62.67
JAN 19	20.44	85.16	20.14	83.90	19.36	80.68	17.01	70.86
JAN 20	21.48	89.52	21.20	88.33	20.51	85.45	18.54	77.26
JAN 21	22.63	94.29	22.34	93.08	21.65	90.20	19.98	83.24
JAN 22	23.71	98.79	23.42	97.59	22.78	94.93	21.34	88.93
JAN 23	24.00	100.00	24.00	100.00	24.00	100.00	22.60	94.18
JAN 24	24.00	100.00	24.00	100.00	24.00	100.00	23.96	99.85
JAN 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JAN 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JAN 13	11.89	49.56	11.58	48.27	11.20	46.67	10.80	45.01
~~JAN 14~~	11.90	49.59	11.61	48.36	11.21	46.70	10.82	45.07
JAN 15	11.91	49.62	11.63	48.45	11.22	46.73	10.83	45.12
~~JAN 16~~	11.92	49.67	11.64	48.52	11.22	46.76	10.84	45.17
JAN 17	11.97	49.88	11.66	48.58	11.23	46.78	10.85	45.22
~~JAN 18~~	12.02	50.07	11.67	48.64	11.23	46.80	10.87	45.28
JAN 19	12.06	50.25	11.69	48.69	11.25	46.88	10.89	45.37
~~JAN 20~~	12.10	50.40	11.70	48.75	11.27	46.98	10.93	45.52
JAN 21	12.13	50.55	11.71	48.77	11.30	47.07	10.96	45.66
~~JAN 22~~	12.15	50.63	11.71	48.80	11.32	47.15	10.99	45.79
JAN 23	12.17	50.70	11.72	48.83	11.34	47.24	11.02	45.90
~~JAN 24~~	17.27	71.97	11.73	48.86	11.36	47.32	11.04	46.00
JAN 25	19.14	79.76	11.73	48.88	11.41	47.53	11.06	46.10
~~JAN 26~~	18.43	76.81	11.73	48.89	11.45	47.72	11.08	46.18

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
JAN 27	24.00	100.00	24.00	100.00	24.00	100.00	22.92	95.49
JAN 28	23.73	98.88	23.46	97.76	22.92	95.48	21.72	90.51
JAN 29	22.71	94.64	22.44	93.51	21.86	91.10	20.47	85.30
JAN 30	21.70	90.42	21.43	89.28	20.81	86.71	19.15	79.81
JAN 31	20.69	86.21	20.41	85.04	19.72	82.19	17.67	73.62
FEB 1	19.66	81.92	19.36	80.68	18.59	77.46	15.70	65.40
FEB 2	18.59	77.44	18.25	76.04	17.36	72.34	12.90	53.75
FEB 3	17.48	72.82	17.14	71.42	15.98	66.58	12.71	52.97
FEB 4	16.39	68.28	15.94	66.43	14.27	59.44	12.71	52.97
FEB 5	15.23	63.47	14.70	61.26	13.37	55.72	12.72	52.98
FEB 6	14.17	59.02	13.71	57.14	13.30	55.43	12.72	53.01
FEB 7	13.75	57.27	13.71	57.11	13.31	55.46	12.73	53.04
FEB 8	13.75	57.27	13.71	57.12	13.33	55.56	12.74	53.06
FEB 9	13.75	57.28	13.71	57.13	13.36	55.66	12.74	53.09

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JAN 27	15.20	63.35	11.74	48.91	11.49	47.89	11.10	46.26
JAN 28	12.20	50.85	11.74	48.93	11.53	48.04	11.12	46.34
JAN 29	12.21	50.88	11.75	48.94	11.56	48.17	11.14	46.40
JAN 30	12.22	50.91	11.77	49.06	11.59	48.28	11.15	46.46
JAN 31	12.22	50.93	11.81	49.20	11.61	48.38	11.17	46.52
FEB 1	12.23	50.95	11.84	49.33	11.63	48.47	11.18	46.58
FEB 2	12.23	50.97	11.90	49.59	11.65	48.54	11.19	46.63
FEB 3	12.24	50.99	11.96	49.81	11.67	48.61	11.20	46.68
FEB 4	12.24	51.00	12.00	50.01	11.68	48.67	11.21	46.72
FEB 5	12.24	51.02	12.04	50.17	11.69	48.72	11.22	46.77
FEB 6	12.26	51.09	12.08	50.32	11.70	48.76	11.23	46.81
FEB 7	12.30	51.25	12.11	50.44	11.71	48.80	11.26	46.92
FEB 8	12.34	51.40	12.13	50.55	11.72	48.83	11.30	47.07
FEB 9	12.39	51.62	12.15	50.63	11.73	48.86	11.33	47.21

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6		GREATER THAN 1.5x10EXP=5		GREATER THAN 1.5x10EXP=4		GREATER THAN 1.5x10EXP=3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
FEB 10	13.75	57.28	13.71	57.14	13.38	55.75	12.75	53.14
~~FEB 11~~	14.00	58.31	13.94	58.09	13.46	56.10	12.79	53.31
FEB 12	15.11	62.98	14.34	59.76	13.52	56.34	12.83	53.45
~~FEB 13~~	16.20	67.52	15.70	65.40	13.65	56.89	12.88	53.67
FEB 14	17.25	71.87	16.89	70.37	15.41	64.21	12.99	54.11
~~FEB 15~~	18.38	76.58	18.01	75.03	16.89	70.37	13.11	54.64
FEB 16	19.46	81.07	19.13	79.71	18.18	75.75	14.44	60.15
FEB 17	20.54	85.60	20.22	84.23	19.42	80.93	16.68	69.52
FEB 18	21.69	90.36	[illegible].37	89.04	20.63	85.96	18.45	76.89
~~FEB 19~~	22.72	94.67	22.43	93.45	21.75	90.61	19.93	83.03
FEB 20	23.70	98.76	23.42	97.57	22.78	94.93	21.25	88.55
FEB 21	24.00	100.00	24.00	100.00	23.76	99.00	22.44	93.50
FEB 22	24.00	100.00	24.00	100.00	24.00	100.00	23.44	97.65
FEB 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=2		GREATER THAN 1.5x10EXP=1		GREATER THAN 1.5x10EXP=0		GREATER THAN 1.5x10EXP=1	
FEB 10	12.44	51.84	12.17	50.71	11.73	48.89	11.38	47.43
~~FEB 11~~	12.49	52.05	12.19	50.77	11.74	48.91	11.43	47.62
FEB 12	12.53	52.21	12.20	50.82	11.77	49.04	11.47	47.80
~~FEB 13~~	12.57	52.37	12.21	50.87	11.82	49.28	11.51	47.95
FEB 14	12.60	52.50	12.22	50.90	11.85	49.39	11.54	48.08
~~FEB 15~~	12.63	52.62	12.22	50.93	11.88	49.52	11.57	48.19
FEB 16	12.66	52.74	12.23	50.94	11.93	49.70	11.59	48.30
~~FEB 17~~	12.68	52.84	12.24	50.98	11.98	49.92	11.61	48.39
FEB 18	12.70	52.91	12.27	51.12	12.02	50.10	11.63	48.47
~~FEB 19~~	12.71	52.98	12.32	51.33	12.06	50.25	11.65	48.54
FEB 20	12.73	53.04	12.36	51.50	12.09	50.38	11.67	48.61
FEB 21	12.73	53.06	12.39	51.64	12.12	50.49	11.68	48.67
FEB 22	15.23	63.46	12.42	51.75	12.14	50.57	11.70	48.73
FEB 23	18.52	77.19	12.44	51.83	12.16	50.35	11.73	48.87

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
FEB 24	24.0[illegible]	100.00	24.00	100.00	24.00	100.00	24.[illegible]	100.00
FEB 25	24.0[illegible]	100.00	24.00	100.00	24.00	100.00	23.55	98.03
FEB 26	24.0[illegible]	100.00	23.96	99.83	23.42	97.58	22.34	93.09
FEB 27	23.2[illegible]	96.65	22.93	95.58	22.38	93.25	21.11	87.98
FEB 28	22.1[illegible]	[illegible]2.42	21.91	91.31	21.31	88.80	19.77	82.37
MAR 1	21.1[illegible]	88.08	20.87	86.94	20.20	84.16	18.21	75.88
MAR 2	[illegible]	83.40	19.75	82.29	19.04	79.32	16.31	67.93
MAR 3	18.97	79.02	18.66	77.74	17.79	74.13	13.63	56.80
MAR 4	17.9[illegible]	74.57	17.52	73.[illegible]	16.46	68.58	13.47	56.12
MAR 5	16.8[illegible]	70.14	16.43	68.47	15.04	62.68	13.46	56.09
MAR 6	15.[illegible]	66.07	15.39	64.14	14.16	59.01	13.47	56.12
MAR 7	14.94	62.24	14.47	60.36	14.06	58.59	13.48	56.15
MAR 8	14.5	60.40	14.46	60.24	14.07	58.61	13.48	56.18
MAR 9	14.5[illegible]	60.40	14.46	60.28	14.10	58.74	13.49	56.21

	GREATER THAN 1.5x10EXP+2		GREATER THAN 1.5x10EXP+1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
FEB 24	19.22	80.08	12.46	51.90	12.17	50.72	11.78	49.07
FEB 25	16.98	70.74	12.49	52.03	12.19	50.77	11.82	49.23
FEB 26	12.93	53.85	12.53	52.21	12.20	50.82	11.85	49.37
FEB 27	12.94	53.91	12.56	52.35	12.23	50.97	11.88	49.48
FEB 28	12.95	53.96	12.59	52.47	12.29	51.21	11.90	49.58
MAR 1	12.96	54.00	12.62	52.57	12.34	51.41	11.92	49.66
MAR 2	12.97	54.04	12.64	52.66	12.37	51.55	11.94	49.74
MAR 3	12.98	54.07	12.66	52.74	12.40	51.67	11.95	49.80
MAR 4	12.98	54.10	12.69	52.89	12.42	51.76	11.97	49.86
MAR 5	12.99	54.13	12.76	53.18	12.44	51.84	11.99	49.95
MAR 6	13.02	54.20	12.82	53.40	12.45	51.90	12.02	50.09
MAR 7	13.05	54.39	12.86	53.58	12.47	51.94	12.05	50.22
MAR 8	13.0[illegible]	54.51	12.89	53.72	12.48	51.98	12.09	50.37
MAR 9	13.1[illegible]	54.82	12.92	53.82	12.48	52.01	12.15	50.64

DAY OF THE YEAR	GREATER THAN 1.5x10EXP•6		GREATER THAN 1.5x10EXP•5		GREATER THAN 1.5x10EXP•4		GREATER THAN 1.5x10EXP•3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
MAR 10	14.50	60.40	14.46	60.26	14.13	58.89	13.50	56.23
~~MAR 11~~	14.50	60.40	14.47	60.27	14.16	58.99	13.51	56.27
MAR 12	14.99	62.47	14.92	62.16	14.30	59.59	13.59	56.62
~~MAR 13~~	15.29	63.70	14.93	62.22	14.35	59.78	13.66	56.91
MAR 14	16.45	68.56	15.84	66.00	14.46	60.26	13.73	57.19
MAR 15	17.59	73.29	17.12	71.35	15.25	63.56	13.80	57.49
MAR 16	18.71	77.98	18.33	76.39	16.98	70.75	13.88	57.83
MAR 17	19.86	82.77	19.47	81.12	18.43	76.79	14.13	58.85
MAR 18	20.95	87.29	20.62	85.90	19.71	82.13	16.43	68.47
MAR 19	21.96	91.51	21.65	90.22	20.88	86.99	18.42	76.74
MAR 20	22.88	95.33	22.58	94.08	21.90	91.24	19.91	82.95
MAR 21	23.67	98.63	23.39	97.47	22.78	94.91	21.15	88.12
MAR 22	24.00	100.00	24.00	100.00	23.56	98.15	22.19	92.48
MAR 23	24.00	100.00	24.00	100.00	24.00	100.00	23.08	96.17

	GREATER THAN 1.5x10EXP•2		GREATER THAN 1.5x10EXP•1		GREATER THAN 1.5x10EXP•0		GREATER THAN 1.5x10EXP•1	
MAR 10	13.22	55.10	12.94	53.90	12.49	52.04	12.21	50.87
~~MAR 11~~	13.28	55.32	12.95	53.97	12.50	52.06	12.25	51.05
MAR 12	13.32	55.51	12.95	54.01	12.53	52.20	12.29	51.21
~~MAR 13~~	13.36	55.66	12.97	54.05	12.61	52.53	12.32	51.34
MAR 14	13.39	55.78	12.98	54.08	12.68	52.84	12.35	51.45
~~MAR 15~~	13.41	55.89	12.99	54.11	12.74	53.07	12.37	51.55
MAR 16	13.43	55.96	12.99	54.13	12.78	53.27	12.39	51.63
~~MAR 17~~	13.45	56.03	13.04	54.34	12.82	53.43	12.41	51.70
MAR 18	13.46	56.09	13.10	54.57	12.85	53.55	12.43	51.77
~~MAR 19~~	13.47	56.15	13.14	54.75	12.88	53.65	12.44	51.83
MAR 20	13.48	56.19	13.17	54.88	12.90	53.74	12.45	51.89
~~MAR 21~~	13.53	56.37	13.19	54.98	12.91	53.81	12.50	52.10
MAR 22	13.59	56.61	13.22	55.08	12.93	53.88	12.55	52.30
~~MAR 23~~	13.63	56.79	13.27	55.27	12.94	53.93	12.59	52.46

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x 10EXP-4		GREATER THAN 1.5x 10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
MAR 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 27	24.00	100.00	24.00	100.00	24.00	100.00	22.91	95.45
MAR 28	23.66	98.57	23.41	97.54	22.87	95.27	21.66	90.25
MAR 29	22.57	94.06	22.35	93.12	21.75	90.62	20.25	84.40
MAR 30	21.49	89.52	21.22	88.41	20.63	85.95	18.69	77.86
MAR 31	20.45	85.19	20.15	83.97	19.46	81.09	16.81	70.05
APR 1	19.40	80.82	19.07	79.46	18.28	76.19	14.51	60.47
APR 2	18.41	76.69	18.06	75.25	17.15	71.46	14.34	59.76
APR 3	17.4[illegible]	72.81	17.14	71.42	16.03	66.79	14.29	59.53
APR 4	16.94	70.59	16.53	68.88	15.27	63.61	14.29	59.53
APR 5	16.21	67.54	15.72	65.50	15.12	62.99	14.35	59.77
APR 6	15.74	65.60	15.68	65.31	15.11	62.95	14.41	60.05

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x10EXP+1	
MAR 24	17.23	71.77	13.30	55.43	12.97	54.02	12.62	52.59
MAR 25	19.02	79.23	13.33	55.55	13.03	54.30	12.65	52.69
MAR 26	17.80	74.17	13.36	55.65	13.09	54.53	12.67	52.79
MAR 27	13.73	57.20	13.38	55.74	13.12	54.68	12.69	52.86
MAR 28	13.74	57.23	13.40	55.83	13.15	54.80	12.70	52.93
MAR 29	13.74	57.25	13.46	56.09	13.18	54.90	12.72	52.99
MAR 30	13.74	57.27	13.53	56.37	13.19	54.97	12.73	53.04
MAR 31	13.77	57.38	13.58	56.58	13.21	55.03	12.76	53.16
APR 1	13.80	57.51	13.62	56.75	13.22	55.07	12.79	53.30
APR 2	13.88	57.84	13.65	56.88	13.23	55.11	12.85	53.53
APR 3	13.95	58.13	13.67	56.97	13.23	55.14	12.91	53.80
APR 4	14.01	58.37	13.69	57.05	13.24	55.17	12.96	54.01
APR 5	14.05	58.56	13.71	57.11	13.25	55.20	13.01	54.19
APR 6	14.09	58.73	13.72	57.15	13.31	55.45	13.04	54.34

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
APR 7	15.74	65.59	15.68	65.32	15.13	63.05	14.47	60.29
~~APR 8~~	15.74	65.60	15.68	65.34	15.16	63.15	14.52	60.50
APR 9	15.74	65.60	15.68	65.35	15.18	63.24	14.56	60.68
~~APR 10~~	15.94	~~65.60~~	15.69	65.36	15.20	63.31	14.60	60.82
APR 11	15.74	65.60	15.69	65.38	15.21	63.39	14.63	60.95
~~APR 12~~	16.73	69.71	15.91	66.31	15.25	63.55	14.65	61.06
APR 13	17.94	74.76	17.39	72.46	15.46	64.41	14.68	61.17
~~APR 14~~	19.11	79.62	18.67	77.78	17.14	71.42	14.71	61.30
APR 15	20.19	84.11	19.81	82.53	18.67	77.79	14.77	61.53
~~APR 16~~	21.41	89.20	21.03	87.63	19.98	83.26	15.95	66.46
APR 17	22.22	92.59	21.91	91.29	21.04	87.67	18.16	75.68
~~APR 18~~	22.96	95.67	22.67	94.44	21.92	91.33	19.74	82.25
APR 19	23.58	98.26	23.33	97.20	22.65	94.39	20.90	87.08
~~APR 20~~	24.00	100.00	23.92	99.66	23.30	97.09	21.84	91.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
APR 7	14.13	58.86	13.73	57.19	13.38	55.74	13.07	54.47
~~APR 8~~	14.15	58.97	13.73	57.22	13.45	56.03	13.10	54.58
APR 9	14.17	59.06	13.74	57.24	13.50	56.25	13.12	54.67
~~APR 10~~	14.19	59.13	13.76	57.33	13.55	56.44	13.14	54.76
APR 11	14.20	59.18	13.82	57.59	13.58	56.59	13.16	54.83
~~APR 12~~	14.21	59.23	13.87	57.78	13.61	56.71	13.18	54.90
APR 13	14.22	59.27	13.90	57.93	13.63	56.81	13.19	54.96
~~APR 14~~	14.24	59.35	13.93	58.04	13.66	56.90	13.20	55.02
APR 15	14.31	59.61	13.96	58.18	13.67	56.97	13.25	55.19
~~APR 16~~	14.35	59.80	14.02	58.40	13.69	57.03	13.29	55.38
APR 17	14.39	59.95	14.06	58.58	13.70	57.08	13.33	55.53
~~APR 18~~	14.42	60.07	14.10	58.73	13.[illegible]	57.13	13.36	55.66
APR 19	14.47	60.30	14.12	58.85	13.77	57.36	13.39	55.77
~~APR 20~~	14.55	60.62	14.15	58.95	13.82	57.59	13.41	55.86

DAY OF THE YEAR		GREATER THAN 1.5x 10EXP-6		GREATER THAN 1.5x 10EXP-5		GREATER THAN 1.5x 10EXP-4		GREATER THAN 1.5x 10EXP-3	
		HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
APR	21	24.00	100.00	24.00	100.00	24.00	100.00	22.67	94.45
APR	22	24.00	100.00	24.00	100.00	24.00	100.00	23.41	97.53
APR	23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	25	24.00	100.00	24.00	100.00	24.00	100.00	23.53	98.02
APR	26	24.00	100.00	24.00	100.00	23.42	97.58	22.16	92.33
APR	27	23.22	96.73	22.94	95.57	22.32	92.99	20.77	86.54
APR	28	22.17	92.37	21.88	91.16	21.18	88.27	19.28	80.33
APR	29	21.16	88.15	20.85	86.89	20.12	83.85	17.69	73.72
APR	30	20.21	84.22	19.91	82.97	19.14	79.74	16.03	66.80
MAY	1	19.41	80.88	19.09	79.53	18.22	75.91	15.40	64.16
MAY	2	18.68	77.85	18.35	76.48	17.36	72.33	15.34	63.90
MAY	3	17.99	74.97	17.67	73.64	16.49	68.71	15.35	63.95
MAY	4	17.44	72.67	17.04	71.02	16.10	67.08	15.36	63.99
		GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x 10EXP+1	
APR	21	14.60	60.83	14.17	59.04	13.86	57.74	13.43	55.94
APR	22	14.63	60.95	14.18	59.10	13.89	57.88	13.44	56.01
APR	23	16.79	69.95	14.20	59.16	13.91	57.96	13.47	56.12
APR	24	18.05	75.23	14.26	59.41	13.93	58.04	13.51	56.28
APR	25	14.62	60.93	14.31	59.63	13.95	58.11	13.54	56.41
APR	26	14.64	61.02	14.35	59.80	13.96	58.16	13.57	56.54
APR	27	14.71	61.27	14.38	59.94	13.97	58.20	13.59	56.65
APR	28	14.75	61.48	14.41	60.04	13.98	58.24	13.62	56.74
APR	29	14.79	61.64	14.43	60.12	14.02	58.41	13.64	56.83
APR	30	14.83	61.78	14.45	60.19	14.06	58.57	13.69	57.02
MAY	1	14.85	61.90	14.46	60.24	14.09	58.71	13.73	57.20
MAY	2	14.88	62.00	14.47	60.28	14.12	58.83	13.77	57.36
MAY	3	14.91	62.10	14.48	60.32	14.14	58.93	13.80	57.49
MAY	4	14.92	62.18	14.48	60.35	14.18	59.08	13.82	57.60

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
MAY 5	16.84	70,19	16.47	68.61	16.01	66,72	15.38	64.08
~~MAY 6~~	16.50	68,73	16.45	68.54	16.02	66,74	15.40	64,16
MAY 7	16.50	68,73	16.45	68.55	16.04	66,83	15.42	64.2
~~MAY 8~~	16.74	69,76	16.68	69.52	16.11	67,13	15.44	64.32
MAY 9	16.74	69,77	16.69	69.53	16.15	67,27	15.45	64,38
~~MAY 10~~	16.74	69,77	16.69	69.54	16.18	67,41	15.46	64.43
MAY 11	17.04	71.00	16.70	69.59	16.22	67,58	15.47	64,47
~~MAY 12~~	18.49	77.03	17.81	74.21	16.37	68,22	15.50	64.60
MAY 13	19.58	81.58	19.07	79.45	17.00	70,84	15.57	64.89
~~MAY 14~~	20.48	85,35	20.10	83.75	18.63	77,62	15.66	65.24
MAY 15	21.26	88,65	20.93	87.23	19.83	82,62	15.82	65.93
~~MAY 16~~	21.97	91.54	21.66	90.26	20.75	8[illegible],46	17.45	72.72
MAY 17	22.55	93.98	22.28	92.84	21.51	89,63	19.04	79.32
~~MAY 18~~	23.13	96,37	22.86	95.25	22.15	92,30	20.14	83,91

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
MAY 5	14,94	62,24	14.50	60.43	14.23	59,31	13,85	57,70
~~MAY 6~~	14,95	62,30	14.55	60.62	14.28	59,49	13,87	57,79
MAY 7	14,96	62,35	14.56	60.77	14.32	59,65	13,89	57,87
~~MAY 8~~	14,97	62,39	14,61	60.90	14.34	59,77	13,90	57,94
MAY 9	14,98	62,42	14,64	61.00	14.37	59,87	13,92	58,00
~~MAY 10~~	15,00	62,50	14.67	61.12	14.39	59,96	13,93	58,05
MAY 11	15,04	62,68	14,72	61.35	14.41	60,03	13,95	58,10
~~MAY 12~~	15.08	62,84	14,77	61.53	14.42	60,10	13,96	58,15
MAY 13	15.11	62,97	14,80	61,69	14,44	60,15	13,97	58,20
~~MAY 14~~	15.14	63,08	14.83	61.81	14.45	60,19	14.00	58,35
MAY 15	15.17	63,19	14,86	61.92	14.46	60,23	14,04	58,48
~~MAY 16~~	15,20	63,38	14,88	62.01	14,46	60,27	14.07	58.61
MAY 17	15,25	63,53	14,90	62.09	14,47	60,30	14,09	58,70
~~MAY 18~~	15,29	63,69	14,92	62.15	14.50	60,41	14,11	58,79

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
MAY 19	23.65	98.54	23.39	97.45	22.74	94.74	21.04	87.68
MAY 20	24.00	100.00	23.92	99.67	23.31	97.14	21.86	91.08

	GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x 10EXP+1	
MAY 19	15.32	63.83	14.93	62.20	14.54	60.58	14.13	58.87
MAY 20	15.34	63.93	14.94	62.24	14.57	60.72	14.15	58.95

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TABLE 3

Number of Hours in which Illumination
Exceeds a Given Level

Sixty-Degree Latitude

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME o/o	GREATER THAN 1.5x10EXP-5 HOURS	TIME o/o	GREATER THAN 1.5x10EXP-4 HOURS	TIME o/o	GREATER THAN 1.5x10EXP-3 HOURS	TIME o/o
MAY 20	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 21	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 22	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 27	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 31	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 1	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 2	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME o/o	GREATER THAN 1.5x10EXP-1 HOURS	TIME o/o	GREATER THAN 1.5x10EXP+0 HOURS	TIME o/o	GREATER THAN 1.5x10EXP+1 HOURS	TIME o/o
MAY 20	22.16	92.33	20.44	85.15	19.36	80.68	18.33	76.38
MAY 21	22.41	93.38	20.56	85.73	19.45	81.02	18.40	76.67
MAY 22	22.72	94.67	20.71	86.29	19.55	81.47	18.48	77.02
MAY 23	23.10	96.24	20.84	86.84	19.64	81.84	18.57	77.36
MAY 24	23.92	99.67	20.97	87.36	19.75	82.30	18.64	77.66
MAY 25	24.00	100.00	21.10	87.93	19.84	82.68	18.72	78.01
MAY 26	24.00	100.00	21.24	88.48	19.93	83.05	18.80	78.33
MAY 27	24.00	100.00	21.37	89.03	20.04	83.49	18.87	78.61
MAY 28	24.00	100.00	21.52	89.68	20.12	83.85	18.95	78.94
MAY 29	24.00	100.00	21.65	90.22	20.20	84.17	19.02	79.26
MAY 30	24.00	100.00	21.79	90.80	20.29	84.55	19.09	79.54
MAY 31	24.00	100.00	21.96	91.48	20.38	84.91	19.15	79.78
JUN 1	24.00	100.00	22.11	92.11	20.48	85.34	19.20	79.99
JUN 2	24.00	100.00	22.24	92.67	20.57	85.69	19.26	80.24

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JUN 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 4	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 5	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 6	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 7	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 8	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 9	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 10	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 11	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 12	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 13	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 14	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 15	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 16	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JUN 3	24.00	100.00	22.42	93.42	20.64	86.00	19.32	80.49
JUN 4	24.00	100.00	22.59	94.11	20.70	86.25	19.39	80.79
JUN 5	24.00	100.00	22.73	94.73	20.76	86.50	19.45	81.06
JUN 6	24.00	100.00	22.96	95.66	20.85	86.86	19.51	81.30
JUN 7	24.00	100.00	23.17	96.54	20.93	87.22	19.56	81.49
JUN 8	24.00	100.00	23.47	97.81	21.00	87.51	19.60	81.66
JUN 9	24.00	100.00	24.00	100.00	21.06	87.77	19.63	81.81
JUN 10	24.00	100.00	24.00	100.00	21.12	87.98	19.67	81.94
JUN 11	24.00	100.00	24.00	100.00	21.16	88.16	19.69	82.06
JUN 12	24.00	100.00	24.00	100.00	21.20	88.32	19.72	82.17
JUN 13	24.00	100.00	24.00	100.00	21.24	88.49	19.75	82.31
JUN 14	24.00	100.00	24.00	100.00	21.28	88.67	19.78	82.43
JUN 15	24.00	100.00	24.00	100.00	21.31	88.81	19.81	82.53
JUN 16	24.00	100.00	24.00	100.00	21.34	88.93	19.83	82.61

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
JUN 17	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 18	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 19	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 20	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 21	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 22	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 27	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUN 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
JUN 17	24.00	100.00	24.00	100.00	21.36	89.01	19.84	82.67
JUN 18	24.00	100.00	24.00	100.00	21.36	89.08	19.85	82.71
JUN 19	24.00	100.00	24.00	100.00	21.39	89.12	19.86	82.74
JUN 20	24.00	100.00	24.00	100.00	21.39	89.13	19.86	82.76
JUN 21	24.00	100.00	24.00	100.00	21.39	89.13	19.86	82.76
JUN 22	24.00	100.00	24.00	100.00	21.38	89.10	19.86	82.74
JUN 23	24.00	100.00	24.00	100.00	21.37	89.04	19.85	82.70
JUN 24	24.00	100.00	24.00	100.00	21.35	88.97	19.84	82.65
JUN 25	24.00	100.00	24.00	100.00	21.33	88.87	19.82	82.59
JUN 26	24.00	100.00	24.00	100.00	21.30	88.74	19.80	82.51
JUN 27	24.00	100.00	24.00	100.00	21.26	88.58	19.78	82.41
JUN 28	24.00	100.00	24.00	100.00	21.21	88.38	19.75	82.28
JUN 29	24.00	100.00	24.00	100.00	21.16	88.15	19.71	82.13
JUN 30	24.00	100.00	24.00	100.00	21.09	87.87	19.67	81.96

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
JUL 1	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 2	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 4	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 5	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 6	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 7	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 8	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 9	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 10	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 11	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 12	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 13	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 14	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
JUL 1	24.00	100.00	23.99	99.96	21.02	87.59	19.62	81.76
JUL 2	24.00	100.00	23.42	97.59	20.96	87.35	19.57	81.54
JUL 3	24.00	100.00	23.15	96.48	20.91	87.14	19.52	81.35
JUL 4	24.00	100.00	22.92	95.52	20.86	86.90	19.47	81.15
JUL 5	24.00	100.00	22.74	94.76	20.79	86.61	19.43	80.95
JUL 6	24.00	100.00	22.55	93.96	20.71	86.27	19.38	80.76
JUL 7	24.00	100.00	22.39	93.28	20.61	85.89	19.33	80.55
JUL 8	24.00	100.00	22.23	92.63	20.54	85.59	19.27	80.30
JUL 9	24.00	100.00	22.07	91.97	20.46	85.23	19.20	80.02
JUL 10	24.00	100.00	21.92	91.32	20.37	84.88	19.13	79.73
JUL 11	24.00	100.00	21.78	90.74	20.29	84.54	19.08	79.49
JUL 12	24.00	100.00	21.63	90.13	20.19	84.14	19.01	79.21
JUL 13	24.00	100.00	21.50	89.58	20.11	83.80	18.94	78.90
JUL 14	24.00	100.00	21.35	88.95	20.03	83.46	18.85	78.56

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DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
JUL 15	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 16	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 17	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 18	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 19	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 20	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 21	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 22	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 27	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JUL 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP+1 HOURS	TIME 0/0
JUL 15	24.00	100.00	21.21	88.37	19.92	83.02	18.78	78.26
JUL 16	24.00	100.00	21.09	87.89	19.82	82.58	18.70	77.91
JUL 17	23.65	98.57	20.96	87.34	19.72	82.16	18.64	77.66
JUL 18	23.06	96.07	20.81	86.70	19.64	81.85	18.57	77.38
JUL 19	22.67	94.47	20.68	86.18	19.56	81.50	18.49	77.04
JUL 20	22.39	93.28	20.58	85.74	19.45	81.06	18.40	76.66
JUL 21	22.14	92.24	20.45	85.19	19.32	80.52	18.30	76.23
JUL 22	21.91	91.29	20.28	84.52	19.22	80.08	18.21	75.88
JUL 23	21.69	90.35	20.18	84.07	19.15	79.80	18.15	75.62
JUL 24	21.51	89.63	20.08	83.66	19.07	79.45	18.08	75.32
JUL 25	21.28	88.67	19.95	83.11	18.96	79.00	17.99	74.97
JUL 26	21.14	88.08	19.78	82.41	18.82	78.42	17.89	74.54
JUL 27	20.97	87.38	19.68	82.02	18.72	77.99	17.77	74.04
JUL 28	20.76	86.48	19.59	81.63	18.65	77.71	17.70	73.74

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
JUL 29	24.00	100.00	24.00	100.00	24.00	100.00	23.16	96.51
JUL 30	24.00	100.00	24.00	100.00	24.00	100.00	22.85	95.22
JUL 31	24.00	100.00	24.00	100.00	24.00	100.00	23.48	97.85
AUG 1	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 2	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 3	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 4	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 5	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
AUG 6	24.00	100.00	24.00	100.00	24.00	100.00	22.90	95.40
AUG 7	24.00	100.00	24.00	100.00	24.00	100.00	21.99	91.63
AUG 8	24.00	100.00	24.00	100.00	24.00	100.00	21.16	88.15
AUG 9	24.00	100.00	24.00	100.00	24.00	100.00	20.61	85.87
AUG 10	24.00	100.00	24.00	100.00	24.00	100.00	20.30	84.57
AUG 11	24.00	100.00	24.00	100.00	24.00	100.00	20.05	83.56

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
JUL 29	20.64	86.00	19.47	81.11	18.57	77.36	17.63	73.46
JUL 30	20.50	85.40	19.30	80.40	18.45	76.88	17.55	73.13
JUL 31	20.30	84.59	19.20	79.99	18.30	76.27	17.46	72.75
AUG 1	20.19	84.12	19.11	79.64	18.21	75.89	17.[illegible]	72.26
AUG 2	20.09	83.71	19.00	79.17	18.14	75.60	[illegible]	71.80
AUG 3	19.95	83.12	18.84	78.52	18.06	75.25	[illegible]	71.54
AUG 4	19.77	82.39	18.72	77.99	17.94	74.75	17.[illegible]0	71.23
AUG 5	19.65	81.89	18.65	77.69	17.76	74.10	[illegible]	70.86
AUG 6	19.53	81.38	18.54	77.26	17.71	73.78	[illegible]	70.41
AUG 7	19.34	80.57	18.40	76.68	17.64	73.49	[illegible].76	69.84
AUG 8	19.20	80.00	18.24	75.99	17.55	73.13	16.70	69.57
AUG 9	19.09	79.56	18.18	75.73	17.43	72.61	16.63	69.28
AUG 10	18.95	78.97	18.09	75.37	17.27	71.95	16.54	68.93
AUG 11	18.76	78.18	17.97	74.86	17.20	71.67	16.44	68.51

DAY OF THE YEAR		GREATER THAN 1.5x 10EXP-6		GREATER THAN 1.5x 10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x 10EXP-3	
		HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
AUG	12	24.00	100.00	24.00	100.00	24.00	100.00	19.82	82.58
AUG	13	24.00	100.00	24.00	100.00	22.90	95.42	19.67	81.96
AUG	14	24.00	100.00	24.00	100.00	22.33	93.03	19.54	81.41
AUG	15	24.00	100.00	24.00	100.00	21.99	91.63	19.36	80.66
AUG	16	24.00	100.00	24.00	100.00	21.68	90.31	19.21	80.02
AUG	17	24.00	100.00	24.00	100.00	21.41	89.20	19.10	79.58
AUG	18	24.00	100.00	24.00	100.00	21.16	88.15	18.95	78.96
AUG	19	23.24	96.84	23.17	96.54	20.93	87.22	18.78	78.26
AUG	20	22.74	94.76	22.67	94.46	20.70	86.25	18.67	77.78
AUG	21	22.24	92.68	22.17	92.38	20.52	85.48	18.56	77.31
AUG	22	21.99	91.63	21.92	91.34	20.31	84.61	18.40	76.[illegible]7
AUG	23	21.74	90.59	21.67	90.30	20.13	83.87	18.26	76.09
AUG	24	21.49	89.55	21.42	89.25	19.95	83.14	18.15	75.64
AUG	25	21.24	88.51	21.17	88.22	19.79	82.47	18.05	75.[illegible]

		GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
AUG	12	18.6[illegible]	77.82	17.79	74.13	17.13	71.39	16.31	67.97
AUG	13	18.5[illegible]	77.40	17.71	73.78	17.04	71.01	16.22	67.57
AUG	14	18.44	76.82	17.64	73.49	16.92	70.48	16.15	67.30
AUG	15	18.2[illegible]	76.10	17.54	73.07	16.77	69.87	16.07	66.97
AUG	16	18.1[illegible]	75.75	17.39	72.47	16.70	69.57	15.98	66.58
AUG	17	18.0[illegible]	75.30	17.25	71.87	16.63	69.29	15.86	66.07
AUG	18	17.96	74.82	17.18	71.59	16.54	68.91	15.75	65.61
AUG	19	17.8[illegible]	74.16	17.10	71.26	16.41	68.37	15.67	65.31
AUG	20	17.7[illegible]	73.73	16.99	70.79	16.28	67.84	15.60	65.00
AUG	21	17.61	73.39	16.84	70.16	16.20	67.48	15.51	64.63
AUG	22	17.5[illegible]	72.90	16.72	69.68	16.13	67.21	15.39	64.14
AUG	23	17.3[illegible]	72.29	16.66	69.42	16.03	66.81	15.29	63.72
AUG	24	17.2[illegible]	71.80	16.57	69.05	15.90	66.27	15.19	63.30
AUG	25	17.15	71.45	16.44	68.51	15.81	65.86	15.12	63.01

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
AUG 26	21.67	90.29	20.98	87.42	19.85	82.70	17.92	74.66
~~AUG 27~~	22.61	94.20	21.99	91.64	20.19	84.14	17.80	74.18
AUG 28	24.00	100.00	23.52	98.01	22.03	91.77	17.72	73.84
~~AUG 29~~	24.00	100.00	24.00	100.00	24.00	100.00	17.78	74.07
AUG 30	24.00	100.00	24.00	100.00	24.00	100.00	23.56	98.18
AUG 31	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 1	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 2	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
SEP 3	24.00	100.00	24.00	100.00	24.00	100.00	23.10	96.27
SEP 4	24.00	100.00	24.00	100.00	24.00	100.00	22.26	92.73
SEP 5	24.00	100.00	24.00	100.00	24.00	100.00	21.34	88.97
SEP 6	24.00	100.00	24.00	100.00	24.00	100.00	20.04	83.51
SEP 7	24.00	100.00	24.00	100.00	24.00	100.00	17.76	73.98
~~SEP 8~~	24.00	100.00	24.00	100.00	22.40	93.35	16.68	69.50

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
AUG 26	17.05	71.04	16.34	68.07	15.70	65.40	15.04	62.65
AUG 27	16.91	70.44	16.22	67.59	15.63	65.12	14.93	62.19
AUG 28	16.82	70.08	16.14	67.25	15.53	64.72	14.84	61.82
~~AUG 29~~	16.69	69.55	16.04	66.85	15.41	64.22	14.74	61.43
AUG 30	16.61	69.21	15.92	66.33	15.34	63.90	14.64	61.01
~~AUG 31~~	16.51	68.80	15.85	66.03	15.23	63.46	14.56	60.66
SEP 1	16.43	68.47	15.74	65.59	15.13	63.04	14.45	60.21
~~SEP 2~~	16.37	68.20	15.62	65.08	15.03	62.62	14.37	59.89
SEP 3	16.26	67.74	15.52	64.65	14.93	62.22	14.29	59.56
~~SEP 4~~	16.09	67.04	15.43	64.30	14.87	61.95	14.19	59.12
SEP 5	15.97	66.55	15.36	64.01	14.77	61.56	14.08	58.65
~~SEP 6~~	15.91	66.27	15.26	63.59	14.64	61.02	13.97	58.21
SEP 7	15.81	65.87	15.11	62.97	14.52	60.51	13.91	57.95
~~SEP 8~~	15.67	65.29	14.98	62.44	14.45	60.21	13.84	57.65

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x 10EXP-5		GREATER THAN 1.5x 10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
SEP 9	24.00	100.00	23.38	97.43	20.64	86.00	16.40	68.33
SEP 10	22.99	95.78	21.77	90.70	18.22	75.91	16.25	67.72
SEP 11	21.00	87.52	19.71	82.13	17.66	73.59	16.06	66.93
SEP 12	18.81	78.36	17.95	74.79	17.33	72.21	15.96	66.52
SEP 13	17.99	74.97	17.93	74.72	17.17	71.56	15.90	66.24
SEP 14	17.99	74.97	17.93	74.69	17.02	70.91	15.81	65.87
SEP 15	17.99	74.97	17.92	74.67	16.93	70.54	15.68	65.34
SEP 16	17.74	73.93	17.68	73.65	16.84	70.17	15.54	64.76
SEP 17	17.49	72.89	17.43	72.64	16.73	69.69	15.45	64.39
SEP 18	17.49	72.89	17.43	72.61	16.59	69.11	15.39	64.11
SEP 19	17.49	72.88	17.42	72.59	16.48	68.66	15.29	63.73
SEP 20	17.24	71.85	17.18	71.58	16.39	68.29	15.17	63.19
SEP 21	16.99	70.81	16.94	70.57	16.29	67.89	15.08	62.82
SEP 22	17.28	72.01	16.94	70.59	16.22	67.60	14.97	62.38

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x 10EXP+1	
SEP 9	15.50	64.58	14.94	62.26	14.39	59.98	13.74	57.27
SEP 10	15.45	64.37	14.88	62.00	14.31	59.64	13.63	56.78
SEP 11	15.38	64.09	14.78	61.60	14.20	59.16	13.49	56.21
SEP 12	15.29	63.70	14.65	61.02	14.03	58.46	13.44	55.99
SEP 13	15.15	63.14	14.49	60.38	13.97	58.20	13.37	55.71
SEP 14	15.00	62.49	14.45	60.22	13.92	57.98	13.29	55.37
SEP 15	14.95	62.29	14.39	59.98	13.84	57.68	13.18	54.93
SEP 16	14.89	62.03	14.31	59.62	13.74	57.25	13.05	54.39
SEP 17	14.79	61.64	14.18	59.07	13.59	56.64	12.96	54.01
SEP 18	14.66	61.08	14.06	58.58	13.50	56.25	12.90	53.75
SEP 19	14.56	60.66	13.96	58.17	13.43	55.97	12.82	53.43
SEP 20	14.45	60.22	13.91	57.95	13.37	55.70	12.73	53.03
SEP 21	14.39	59.97	13.83	57.61	13.27	55.30	12.62	52.57
SEP 22	14.31	59.61	13.70	57.09	13.15	54.80	12.53	52.22

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
SEP 23	18.39	76.63	17.62	73.43	16.36	68.15	14.90	62.07
~~SEP 24~~	19.74	82.25	17.13	77.73	17.23	71.77	14.83	61.79
SEP 25	21.26	88.60	20.77	86.54	19.38	80.76	14.76	61.49
~~SEP 26~~	22.86	95.23	22.41	93.37	21.23	88.46	14.72	61.34
SEP 27	24.00	100.00	23.76	99.00	22.91	95.47	20.53	85.54
~~SEP 28~~	24.00	100.00	24.00	100.00	24.00	100.00	22.65	94.38
SEP 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~SEP 30~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 1	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~OCT 2~~	24.00	100.00	24.00	100.00	24.00	100.00	23.35	97.31
OCT 3	24.00	100.00	24.00	100.00	24.00	100.00	22.44	93.50
~~OCT 4~~	24.00	100.00	24.00	100.00	24.00	100.00	21.33	88.86
OCT 5	24.00	100.00	24.00	100.00	24.00	100.00	19.82	82.59
~~OCT 6~~	24.00	100.00	24.00	100.00	22.79	94.97	17.71	73.77

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	TIME 0/0
SEP 23	14.18	59.07	13.62	56.76	13.08	54.50	12.43	51.80
~~SEP 24~~	14.11	58.80	13.54	56.41	12.98	54.08	12.35	51.48
SEP 25	14.02	58.43	13.42	55.91	12.89	53.70	12.26	51.10
~~SEP 26~~	~~13.90~~	~~57.96~~	~~13.64~~	~~55.59~~	12.80	53.32	12.16	50.68
SEP 27	13.83	57.61	13.23	55.11	12.69	52.89	12.09	50.39
~~SEP 28~~	13.71	57.13	13.17	54.88	12.64	52.66	12.01	50.04
SEP 29	13.68	56.98	13.11	54.62	12.56	52.35	11.90	49.59
~~SEP 30~~	13.64	56.82	13.02	54.24	12.46	51.90	11.80	49.15
OCT 1	13.57	56.54	12.88	53.68	12.32	51.34	11.70	48.76
~~OCT 2~~	13.46	56.08	~~12.75~~	53.14	12.23	50.94	11.64	48.51
OCT 3	13.30	55.40	12.71	52.95	12.18	50.76	11.57	48.21
~~OCT 4~~	13.22	55.08	12.66	52.75	12.12	50.50	11.48	47.83
OCT 5	13.16	54.85	12.59	52.46	12.04	50.16	11.36	47.34
~~OCT 6~~	13.08	54.51	12.48	52.02	11.92	49.66	11.24	46.82

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
OCT 7	24.00	100.00	23.09	96.20	21.14	88.06	14.51	60.47
OCT 8	22.34	93.09	21.37	89.04	19.24	80.18	13.66	56.94
OCT 9	20.39	84.97	19.55	81.46	16.93	70.55	13.49	56.23
OCT 10	18.54	77.26	17.64	73.51	14.73	61.38	13.33	55.54
OCT 11	16.75	69.81	15.51	64.64	14.43	60.15	13.22	55.10
OCT 12	15.24	63.51	15.17	63.22	14.26	59.43	13.17	54.89
OCT 13	14.99	62.47	14.93	62.20	14.18	59.10	13.11	54.63
OCT 14	14.74	61.43	14.69	61.20	14.12	58.83	13.02	54.27
OCT 15	14.74	61.43	14.68	61.18	14.04	58.50	12.91	53.79
OCT 16	14.74	61.43	14.68	61.16	13.95	58.10	12.83	53.45
OCT 17	14.74	61.43	14.67	61.14	13.85	57.71	12.74	53.07
OCT 18	14.49	60.39	14.43	60.14	13.77	57.39	12.67	52.79
OCT 19	14.49	60.39	14.43	60.12	13.68	57.00	12.61	52.53
OCT 20	14.86	61.91	14.43	60.14	13.64	56.83	12.53	52.19

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	TIME O/O
OCT 7	12.97	54.04	12.33	51.37	11.76	48.99	11.18	46.60
OCT 8	12.81	53.36	12.23	50.97	11.71	48.81	11.12	46.33
OCT 9	12.73	53.03	12.20	50.81	11.67	48.61	11.04	46.00
OCT 10	12.68	52.84	12.14	50.59	11.60	48.33	10.94	45.58
OCT 11	12.62	52.59	12.06	50.26	11.51	47.94	10.81	45.05
OCT 12	12.54	52.25	11.95	49.78	11.37	47.39	10.72	44.66
OCT 13	12.42	51.75	11.83	49.28	11.28	46.98	10.66	44.43
OCT 14	12.32	51.32	11.73	48.87	11.20	46.68	10.59	44.14
OCT 15	12.22	50.91	11.68	48.68	11.15	46.45	10.51	43.78
OCT 16	12.17	50.72	11.63	48.44	11.08	46.16	10.40	43.32
OCT 17	12.11	50.46	11.54	48.09	10.98	45.73	10.31	42.96
OCT 18	12.02	50.10	11.42	47.59	10.87	45.31	10.22	42.57
OCT 19	11.91	49.61	11.35	47.30	10.79	44.98	10.14	42.26
OCT 20	11.83	49.30	11.27	46.94	10.69	44.55	10.07	41.96

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
OCT 21	15.95	66.44	15.09	62.86	13.72	57.16	12.43	51.79
~~OCT 22~~	17.47	72.80	16.84	70.15	14.51	60.45	12.37	51.54
OCT 23	19.08	79.49	18.56	77.34	17.20	71.69	12.31	51.29
~~OCT 24~~	20.66	86.08	20.19	84.13	19.09	79.56	12.25	51.03
OCT 25	22.20	92.49	21.79	90.80	20.77	86.55	16.82	70.10
OCT 26	23.72	98.84	23.36	97.32	22.36	93.16	20.19	84.11
OCT 27	24.00	100.00	24.00	100.00	24.00	100.00	22.10	92.10
OCT 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 29	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 30	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
OCT 31	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
NOV 1	24.00	100.00	24.00	100.00	24.00	100.00	22.53	93.89
NOV 2	24.00	100.00	24.00	100.00	24.00	100.00	21.09	87.88
NOV 3	24.00	100.00	24.00	100.00	23.33	97.21	19.29	[illegible]
	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
OCT 21	11.76	49.02	11.18	46.58	10.64	44.32	9.98	41.58
~~OCT 22~~	11.67	48.64	11.12	46.33	10.56	44.01	9.88	41.17
OCT 23	11.62	48.40	11.04	45.99	10.46	43.58	9.81	40.87
~~OCT 24~~	11.54	48.08	10.93	45.55	10.39	43.28	9.72	40.50
OCT 25	11.44	47.65	10.88	45.33	10.32	42.99	9.63	40.13
~~OCT 26~~	11.39	47.44	10.81	45.03	10.22	42.60	9.56	39.82
OCT 27	11.32	47.18	10.71	44.62	10.14	42.24	9.46	39.43
~~OCT 28~~	11.25	46.88	10.63	44.30	10.07	41.94	9.38	39.10
OCT 29	13.85	57.71	10.56	44.00	9.97	41.54	9.32	38.81
~~OCT 30~~	11.12	46.34	10.46	43.59	9.91	41.28	9.23	38.46
OCT 31	11.03	45.94	10.42	43.40	9.85	41.03	9.13	38.05
~~NOV 1~~	10.97	45.69	10.36	43.16	9.77	40.70	9.06	37.75
NOV 2	10.92	45.50	10.28	42.85	9.67	40.27	8.97	37.39
~~NOV 3~~	10.85	45.23	10.18	42.42	9.59	39.98	8.90	37.07

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
NOV 4	24.00	100.00	23.27	96.94	21.56	89.83	17.20	71.68
NOV 5	22.22	92.57	21.44	89.35	19.73	82.22	14.09	58.70
NOV 6	20.10	83.73	19.44	80.99	17.82	74.25	11.51	47.95
NOV 7	18.35	76.46	17.71	73.79	15.71	65.46	11.31	47.11
NOV 8	16.68	69.49	15.98	66.59	12.86	53.58	11.16	46.48
NOV 9	14.98	62.42	14.01	58.38	12.38	51.58	11.07	46.13
NOV 10	13.21	55.03	12.93	53.89	12.15	50.62	11.00	45.82
NOV 11	12.99	54.13	12.92	53.84	12.07	50.30	10.93	45.56
NOV 12	12.74	53.10	12.68	52.85	12.02	50.07	10.89	45.38
NOV 13	12.74	53.10	12.68	52.83	11.95	49.79	10.84	45.18
NOV 14	12.74	53.09	12.68	52.82	11.91	49.60	10.78	44.93
NOV 15	12.49	52.06	12.44	51.83	11.86	49.41	10.71	44.62
NOV 16	12.49	52.06	12.43	51.81	11.81	49.20	10.65	44.35
NOV 17	12.50	52.07	12.43	51.81	11.76	49.00	10.60	44.18

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
NOV 4	10.76	44.85	10.11	42.11	9.51	39.64	8.83	36.80
NOV 5	10.65	44.35	10.03	41.80	9.44	39.31	8.75	36.48
NOV 6	10.57	44.05	9.95	41.45	9.39	39.11	8.66	36.10
NOV 7	10.49	43.71	9.91	41.28	9.32	38.84	8.59	35.78
NOV 8	10.43	43.47	9.85	41.04	9.24	38.51	8.51	35.46
NOV 9	10.39	43.27	9.78	40.75	9.15	38.11	8.43	35.10
NOV 10	10.33	43.03	9.69	40.36	9.09	37.86	8.37	34.86
NOV 11	10.26	42.74	9.62	40.08	9.01	37.55	8.30	34.59
NOV 12	10.17	42.36	9.56	39.83	8.93	37.23	8.22	34.27
NOV 13	10.11	42.14	9.48	39.51	8.89	37.04	8.14	33.91
NOV 14	10.06	41.91	9.42	39.27	8.83	36.80	8.10	33.75
NOV 15	9.99	41.62	9.38	39.08	8.76	36.51	8.03	33.48
NOV 16	9.93	41.38	9.32	38.85	8.68	36.15	7.96	33.16
NOV 17	9.89	41.19	9.26	38.57	8.63	35.94	7.90	32.93

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	TIME O/O
NOV 18	14.07	58.62	13.05	54.39	11.77	49.04	10.56	44.00
~~NOV 19~~	15.72	65.52	15.04	62.65	11.94	49.74	10.52	43.83
NOV 20	17.37	72.38	16.81	70.05	15.00	62.48	10.50	43.73
~~NOV 21~~	18.70	77.90	18.22	75.90	17.09	71.20	10.51	43.80
NOV 22	20.22	84.27	19.82	82.59	18.84	78.50	12.83	53.45
~~NOV 23~~	21.75	90.64	21.39	89.12	20.47	85.30	17.58	73.26
NOV 24	23.40	97.51	22.96	95.65	22.07	91.96	19.70	82.07
~~NOV 25~~	24.00	100.00	24.00	100.00	24.00	100.00	21.57	89.88
NOV 26	24.00	100.00	24.00	100.00	24.00	100.00	23.75	98.95
~~NOV 27~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
NOV 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~NOV 29~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
NOV 30	24.00	100.00	24.00	100.00	24.00	100.00	22.56	94.01
~~DEC 1~~	24.00	100.00	24.00	100.00	24.00	100.00	20.80	86.66

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP 0		GREATER THAN 1.5x10EXP+1	
NOV 18	9.84	40.98	9.17	38.23	8.57	35.71	7.85	32.70
~~NOV 19~~	9.78	40.74	9.14	38.06	8.51	35.45	7.79	32.44
NOV 20	9.71	40.44	9.09	37.87	8.43	35.14	7.72	32.15
~~NOV 21~~	9.66	40.27	9.04	37.65	8.38	34.92	7.64	31.82
NOV 22	9.63	40.14	8.97	37.39	8.33	34.70	7.59	31.61
~~NOV 23~~	9.60	39.99	8.90	37.09	8.27	34.45	7.53	31.38
NOV 24	9.56	39.84	8.86	36.91	8.20	34.17	7.47	31.13
~~NOV 25~~	9.52	39.66	8.81	36.71	8.18	34.08	7.40	30.85
NOV 26	9.48	39.49	8.75	36.46	8.15	33.95	7.35	30.64
~~NOV 27~~	14.96	62.32	8.71	36.27	8.11	33.80	7.30	30.42
NOV 28	14.22	59.26	8.68	36.17	8.07	33.62	7.25	30.19
~~NOV 29~~	9.37	39.05	8.66	36.06	8.02	33.43	7.19	29.95
NOV 30	9.33	38.86	8.63	35.94	7.98	33.23	7.15	29.80
~~DEC 1~~	9.26	38.60	8.59	35.80	7.92	33.01	7.11	29.64

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
DEC 2	24.00	100.00	23.50	97.91	22.22	92.57	18.87	78.64
DEC 3	22.29	92.86	21.68	90.33	20.47	85.29	16.70	69.60
DEC 4	20.47	85.31	19.94	83.08	18.69	77.86	13.76	57.31
DEC 5	18.81	78.36	18.29	76.22	16.88	70.34	10.08	41.99
DEC 6	17.2[illegible]	71.67	16.66	69.41	14.90	62.09	9.89	41.23
DEC 7	15.6[illegible]	65.03	14.96	62.34	12.18	50.77	9.78	40.75
DEC 8	13.94	58.08	13.03	54.30	11.15	46.46	9.74	40.57
DEC 9	12.15	50.63	11.69	48.71	10.99	45.80	9.72	40.52
DEC 10	11.74	48.93	11.68	48.66	10.95	45.61	9.71	40.47
DEC 11	11.74	48.93	11.68	48.66	10.92	45.52	9.70	40.42
DEC 12	11.74	48.93	11.68	48.66	10.91	45.43	9.69	40.38
DEC 13	11.74	48.93	11.68	48.65	10.88	45.34	9.68	40.34
DEC 14	11.74	48.93	11.68	48.65	10.87	45.29	9.67	40.29
DEC 15	11.74	48.93	11.68	48.65	10.86	45.27	9.66	40.26
	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
DEC 2	9.21	38.35	8.56	35.66	7.86	32.76	7.08	29.49
DEC 3	9.17	38.26	8.52	35.49	7.81	32.55	7.04	29.32
DEC 4	9.1[illegible]	38.15	8.46	35.32	7.77	32.35	7.00	29.16
DEC 5	9.13	38.04	8.43	35.14	7.73	32.21	6.96	28.99
DEC 6	9.11	37.95	8.39	34.94	7.71	32.13	6.92	28.81
DEC 7	9.07	37.81	8.34	34.73	7.69	32.06	6.87	28.64
DEC 8	9.05	37.70	8.29	34.56	7.68	31.98	6.83	28.46
DEC 9	9.02	37.59	8.28	34.50	7.66	31.91	6.79	28.29
DEC 10	9.00	37.49	8.26	34.42	7.64	31.83	6.76	28.18
DEC 11	8.97	37.37	8.24	34.35	7.62	31.76	6.74	28.09
DEC 12	8.95	37.27	8.23	34.29	7.60	31.69	6.72	28.00
DEC 13	8.92	37.17	8.22	34.24	7.59	31.61	6.70	27.93
DEC 14	8.89	37.08	8.21	34.21	7.57	31.54	6.69	27.87
DEC 15	8.89	37.03	8.20	34.17	7.55	31.48	6.68	27.82

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x 10EXP-5		GREATER THAN 1.5x 10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
DEC 16	12.42	51.74	11.69	48.71	10.89	45.39	9.66	40.23
~~DEC 17~~	14.21	59.20	13.41	55.87	11.05	46.03	9.65	40.22
DEC 18	15.89	66.20	15.27	63.64	12.79	53.29	9.68	40.34
~~DEC 19~~	17.46	72.75	16.94	70.58	15.26	63.57	9.76	40.65
DEC 20	18.75	78.10	18.32	76.34	17.17	71.55	9.87	41.15
DEC 21	20.37	84.88	19.91	82.98	18.91	78.81	15.01	62.52
DEC 22	21.99	91.62	21.54	89.76	20.58	85.76	17.49	72.89
~~DEC 23~~	23.79	99.11	23.24	96.85	22.27	92.78	19.56	81.51
DEC 24	24.00	100.00	24.00	100.00	24.00	100.00	21.51	89.63
~~DEC 25~~	24.00	100.00	24.00	100.00	24.00	100.00	23.61	98.36
DEC 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~DEC 27~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
DEC 28	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~DEC 29~~	24.00	100.00	24.00	100.00	24.00	100.00	22.68	94.50

	GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x 10EXP+1	
DEC 16	8.89	37.02	8.19	34.14	7.54	31.42	6.67	27.78
~~DEC 17~~	8.88	37.02	8.19	34.13	7.53	31.38	6.66	27.74
DEC 18	8.89	37.03	8.19	34.13	7.52	31.32	6.65	27.72
~~DEC 19~~	8.89	37.04	8.19	34.13	7.51	31.28	6.65	27.71
DEC 20	8.90	37.07	8.20	34.15	7.50	31.25	6.65	27.72
~~DEC 21~~	8.91	37.11	8.20	34.19	7.50	31.23	6.66	27.74
DEC 22	8.92	37.15	8.22	34.23	7.49	31.22	6.66	27.77
~~DEC 23~~	8.93	37.20	8.23	34.28	7.49	31.22	6.67	27.81
DEC 24	8.94	37.25	8.24	34.33	7.50	31.23	6.69	27.86
~~DEC 25~~	8.95	37.30	8.25	34.40	7.50	31.25	6.70	27.92
DEC 26	13.66	56.93	8.27	34.46	7.51	31.28	6.72	27.99
~~DEC 27~~	15.60	65.00	8.29	34.53	7.52	31.32	6.74	28.07
DEC 28	10.67	44.47	8.30	34.60	7.54	31.43	6.76	28.15
~~DEC 29~~	8.98	37.41	8.32	34.68	7.58	31.57	6.78	28.24

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-6		GREATER THAN 1.5x 10EXP-5		GREATER THAN 1.5x 10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
DEC 30	24.00	100.00	24.00	100.00	23.57	98.20	20.80	86.65
DEC 31	23.37	97.36	22.85	95.20	21.65	90.20	18.83	78.47
JAN 1	21.64	90.16	21.16	88.16	19.97	83.23	16.64	69.33
JAN 2	19.99	83.27	19.55	81.48	18.31	76.29	13.59	56.64
JAN 3	18.44	76.84	17.95	74.78	16.58	68.99	9.98	41.60
JAN 4	16.88	70.33	16.34	68.07	14.53	60.54	9.93	41.39
JAN 5	15.24	63.49	14.60	60.82	11.55	48.13	9.92	41.35
JAN 6	13.55	56.47	12.59	52.45	11.26	46.92	9.93	41.38
JAN 7	11.99	49.98	11.93	49.70	11.15	46.47	9.95	41.45
JAN 8	11.99	49.97	11.93	49.70	11.18	46.60	9.99	41.65
JAN 9	11.99	49.97	11.93	49.71	11.22	46.76	10.04	41.84
JAN 10	11.99	49.97	11.93	49.72	11.26	[illegible]	10.08	42.01
JAN 11	11.99	49.97	11.93	49.73	11.30	47.06	10.12	42.17
JAN 12	12.24	51.01	12.17	50.72	11.33	47.21	10.15	42.30

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
DEC 30	8.95	37.43	8.34	34.76	7.61	31.71	6.80	28.33
DEC 31	8.99	37.46	8.36	34.83	7.65	31.86	6.82	28.43
JAN 1	9.0[illegible]	37.49	8.38	34.91	7.68	32.01	6.85	28.54
JAN 2	9.04	37.65	8.40	34.99	7.72	32.16	6.87	28.65
JAN 3	9.07	37.78	8.41	35.06	7.75	32.30	6.90	28.76
JAN 4	9.10	37.92	8.43	35.13	7.79	2.44	6.93	28.87
JAN 5	9.14	38.08	8.45	35.20	7.82	32.57	6.97	29.02
JAN 6	9.19	38.27	8.49	35.37	7.85	32.71	7.01	29.22
JAN 7	9.23	38.45	8.54	35.58	7.86	32.83	7.06	29.41
JAN 8	9.27	38.63	8.58	35.76	7.91	32.94	7.10	29.59
JAN 9	9.31	38.79	8.62	35.92	7.95	33.11	7.14	29.75
JAN 10	9.34	38.94	8.65	36.06	8.01	33.36	7.19	29.96
JAN 11	9.38	39.07	8.71	36.29	8.06	33.58	7.24	30.19
JAN 12	9.41	39.20	8.77	36.53	8.11	33.78	7.30	30.40

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-3 HOURS	TIME 0/0
JAN 13	12.24	51.01	12.18	50.7[illegible]	11.36	47.35	10.18	42.43
JAN 14	13.10	54.60	12.20	50.85	11.47	47.80	10.24	42.65
JAN 15	14.83	61.80	14.07	58.62	11.74	48.91	10.29	42.89
JAN 16	16.45	68.56	15.87	66.14	13.63	56.80	10.36	43.18
JAN 17	18.05	75.21	17.53	73.05	15.99	66.61	10.53	43.89
JAN 18	19.69	82.04	19.17	7[illegible].87	17.89	74.54	10.96	45.68
JAN 19	21.42	89.24	20.86	[illegible].93	19.69	82.05	15.48	64.52
JAN 20	23.52	98.02	22.86	95.26	21.46	89.40	17.93	74.71
JAN 21	24.00	100.00	24.00	100.00	23.40	97.51	20.02	83.40
JAN 22	24.00	100.00	24.00	100.00	24.00	100.00	21.89	91.22
JAN 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JAN 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JAN 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
JAN 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

	GREATER THAN 1.5x 10EXP-2		GREATER THAN 1.5x 10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x10EXP+1	
JAN 13	9.46	39.43	8.82	36.73	8.15	33.94	7.34	30.60
JAN 14	9.53	39.69	8.86	36.91	8.18	34.09	7.40	30.85
JAN 15	9.58	39.91	8.90	37.07	8.22	34.25	7.47	31.13
JAN 16	9.63	40.11	8.97	37.38	8.28	34.50	7.54	31.40
JAN 17	9.67	40.28	9.04	37.67	8.33	34.72	7.59	31.63
JAN 18	9.70	40.43	9.10	37.90	8.41	35.04	7.64	31.85
JAN 19	9.75	40.62	9.14	38.10	8.49	35.38	7.69	32.04
JAN 20	9.81	40.89	9.18	38.26	8.56	35.66	7.74	32.27
JAN 21	9.93	41.36	9.22	38.40	8.61	35.89	7.81	32.55
JAN 22	10.02	41.77	9.28	38.65	8.66	36.09	7.90	32.94
JAN 23	10.10	42.09	9.34	38.92	8.70	36.25	7.98	33.27
JAN 24	10.16	42.32	9.44	39.33	8.78	36.59	8.05	33.56
JAN 25	15.68	65.33	9.53	39.69	8.86	36.90	8.12	33.82
JAN 26	13.03	54.30	9.59	39.96	8.96	37.33	8.17	34.05

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
JAN 27	24.00	100.00	24.00	100.00	24.00	100.00	23.11	96.28
JAN 28	24.00	100.00	24.00	100.00	23.41	97.56	21.23	88.46
JAN 29	23.00	95.82	22.63	94.30	21.77	90.71	19.27	80.31
JAN 30	21.45	89.39	21.05	87.69	20.16	84.01	16.96	70.67
JAN 31	20.16	84.02	19.70	82.07	18.49	77.06	11.42	47.60
FEB 1	18.59	77.48	18.10	75.41	16.65	69.38	11.34	47.24
FEB 2	16.96	70.73	16.39	68.31	14.32	59.66	11.34	47.23
FEB 3	15.34	63.92	14.55	60.64	12.70	52.90	11.40	47.48
FEB 4	13.65	56.89	13.20	54.98	12.61	52.56	11.49	47.86
FEB 5	13.24	55.18	13.19	54.96	12.65	52.71	11.56	48.18
FEB 6	13.49	56.22	13.43	55.96	12.7[illegible]	52.91	11.62	48.44
FEB 7	13.74	57.26	13.67	56.94	12.75	53.13	11.68	48.65
FEB 8	13.73	57.26	13.67	56.97	12.83	53.46	11.72	48.82
FEB 9	13.74	57.26	13.6[illegible]	56.99	12.93	53.89	11.78	49.10

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
JAN 27	10.25	42.72	9.84	40.19	9.04	37.67	8.22	34.25
JAN 28	10.31	42.95	9.69	40.36	9.11	37.95	8.29	34.55
JAN 29	10.35	43.16	9.72	40.50	9.16	38.17	8.40	34.99
JAN 30	10.45	43.57	9.78	40.76	9.20	38.35	8.49	35.37
JAN 31	10.54	43.90	9.87	41.14	9.25	38.56	8.56	35.68
FEB 1	10.60	44.17	9.98	41.60	9.34	38.92	8.63	35.96
FEB 2	10.65	44.39	10.07	41.95	9.46	39.41	8.69	36.19
FEB 3	10.7[illegible]	44.57	10.13	42.22	9.55	39.78	8.79	36.61
FEB 4	10.73	44.71	10.18	42.42	9.62	40.07	8.89	37.06
FEB 5	10.81	45.03	10.22	42.58	9.67	40.30	8.99	37.46
FEB 6	10.92	45.49	10.28	42.85	9.71	40.48	9.07	37.79
FEB 7	11.02	45.91	10.38	43.26	9.79	40.78	9.14	38.07
FEB 8	11.1[illegible]	46.23	10.50	43.75	9.89	41.20	9.20	38.32
FEB 9	11.1[illegible]	46.48	10.59	44.11	10.00	41.67	9.28	38.65

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP•6		GREATER THAN 1.5x10EXP•5		GREATER THAN 1.5x10EXP•4		GREATER THAN 1.5x10EXP•3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
FEB 10	13.74	57.26	13.68	57.01	13.02	54.24	11.87	49.47
~~FEB 11~~	13.74	57.26	13.69	57.02	13.09	54.54	11.98	49.93
FEB 12	14.45	60.10	13.71	57.11	13.17	54.88	12.07	50.30
FEB 13	16.38	68.26	15.53	64.72	13.33	55.54	12.14	50.59
FEB 14	18.04	75.19	17.39	72.47	14.82	61.76	12.21	50.87
FEB 15	19.74	82.25	19.13	79.72	17.23	71.80	12.35	51.47
FEB 16	21.56	89.83	20.88	86.99	19.24	80.15	12.79	53.28
FEB 17	23.55	98.13	22.68	94.52	21.13	88.05	16.16	67.34
FEB 18	24.00	100.00	24.00	100.00	22.97	95.70	18.82	78.40
FEB 19	24.00	100.00	24.00	100.00	24.00	100.00	20.77	86.56
FEB 20	24.00	100.00	24.00	100.00	24.00	100.00	22.44	93.51
FEB 21	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
FEB 22	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
FEB 23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

	GREATER THAN 1.5x10EXP•2		GREATER THAN 1.5x10EXP•1		GREATER THAN 1.5x10EXP•0		GREATER THAN 1.5x10EXP•1	
FEB 10	11.20	46.67	10.65	44.37	10.09	42.03	9.37	39.04
~~FEB 11~~	11.25	46.88	10.70	44.57	10.15	42.29	9.47	39.48
FEB 12	11.34	47.25	10.74	44.76	10.20	42.50	9.56	39.84
~~FEB 13~~	11.45	47.71	10.84	45.16	10.27	42.79	9.63	40.13
FEB 14	11.55	48.13	10.94	45.60	10.36	43.15	9.69	40.39
~~FEB 15~~	11.63	48.45	11.05	46.04	10.47	43.63	9.78	40.76
FEB 16	11.69	48.69	11.13	46.36	10.57	44.03	9.87	41.11
~~FEB 17~~	11.74	48.91	11.18	46.59	10.64	44.32	9.97	41.56
FEB 18	11.84	49.34	11.24	46.83	10.69	44.54	10.06	41.93
~~FEB 19~~	11.98	49.93	11.34	47.25	10.78	44.92	10.14	42.23
FEB 20	12.10	50.40	11.41	47.54	10.87	45.29	10.21	42.54
~~FEB 21~~	12.17	50.72	11.53	48.04	10.95	45.63	10.31	42.95
FEB 22	12.22	50.92	11.61	48.39	11.05	46.06	10.39	43.27
~~FEB 23~~	12.33	51.36	11.67	48.63	11.13	46.38	10.48	43.67

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
FEB 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
FEB 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
FEB 26	24.00	100.00	24.00	100.00	24.00	100.00	21.85	91.03
FEB 27	23.41	97.54	23.01	95.89	22.20	92.52	19.80	82.49
FEB 28	22.11	92.11	21.69	90.37	20.57	85.72	15.77	65.71
MAR 1	20.51	85.44	20.07	83.61	18.82	78.41	13.48	56.16
MAR 2	18.94	78.92	18.38	76.57	16.76	69.81	13.49	56.22
MAR 3	17.34	72.24	16.61	69.19	14.98	62.44	13.57	56.56
MAR 4	15.82	65.91	15.44	64.35	14.84	61.85	13.68	57.02
MAR 5	15.49	64.56	15.44	64.33	14.90	62.09	13.79	57.48
MAR 6	15.74	65.60	15.68	65.34	14.96	62.34	13.88	57.83
MAR 7	15.99	66.63	15.92	66.35	15.04	62.69	13.94	58.09
MAR 8	15.99	66.64	15.93	66.37	15.18	63.24	13.99	58.28
MAR 9	15.99	66.64	15.93	66.39	15.29	63.71	14.10	58.77

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x 10EXP+0		GREATER THAN 1.5x 10EXP+1	
FEB 24	12.40	51.66	11.77	49.04	11.20	46.66	10.57	44.04
FEB 25	12.44	51.82	11.86	49.42	11.31	47.13	10.64	44.34
FEB 26	12.49	52.06	11.92	49.69	11.39	47.46	10.75	44.79
FEB 27	12.58	52.43	12.00	49.99	11.45	47.69	10.84	45.16
FEB 28	12.66	52.75	12.09	50.38	11.54	48.10	10.91	45.46
MAR 1	12.78	53.25	12.18	50.74	11.62	48.43	10.99	45.78
MAR 2	12.87	53.61	12.30	51.26	11.75	48.95	11.08	46.16
MAR 3	12.93	53.87	12.39	51.61	11.85	49.36	11.19	46.62
MAR 4	12.97	54.05	12.44	51.84	11.91	49.64	11.29	47.05
MAR 5	13.06	54.42	12.48	52.01	11.96	49.85	11.37	47.38
MAR 6	13.20	54.99	12.58	52.40	12.03	50.13	11.44	47.65
MAR 7	13.31	55.46	12.73	53.05	12.17	50.71	11.49	47.89
MAR 8	13.39	55.80	12.84	53.50	12.29	51.22	11.62	48.41
MAR 9	13.45	56.04	12.91	53.80	12.38	51.57	11.74	48.91

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=6 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=5 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=3 HOURS	TIME 0/0
MAR 10	15.99	66.64	15.94	66.41	15.37	64.06	14.24	59.34
~~MAR 11~~	16.49	68.72	16.42	68.41	15.44	64.33	14.34	59.75
MAR 12	16.49	68.72	16.42	68.43	15.52	64.66	14.41	60.06
~~MAR 13~~	16.50	68.73	16.43	68.46	15.67	65.29	14.47	60.28
MAR 14	18.20	75.85	17.15	71.45	15.89	66.22	14.56	60.65
~~MAR 15~~	20.01	83.37	19.17	79.89	16.18	67.43	14.73	61.36
MAR 16	22.18	92.42	21.29	88.72	18.72	77.98	14.88	61.98
~~MAR 17~~	24.00	100.00	23.14	96.40	20.93	87.19	15.11	62.94
MAR 18	24.00	100.00	24.00	100.00	22.88	95.33	16.69	69.54
~~MAR 19~~	24.00	100.00	24.00	100.00	24.00	100.00	19.58	81.58
MAR 20	24.00	100.00	24.00	100.00	24.00	100.00	21.41	89.20
~~MAR 21~~	24.00	100.00	24.00	100.00	24.00	100.00	22.79	94.97
MAR 22	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
~~MAR 23~~	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP=2 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=1 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP=0 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP=1 HOURS	TIME 0/0
MAR 10	13.49	56.20	12.96	54.00	12.44	51.81	11.83	49.28
~~MAR 11~~	13.61	56.72	12.99	54.14	12.48	51.99	11.90	49.58
MAR 12	13.75	57.30	13.15	54.78	12.57	52.39	11.96	49.83
~~MAR 13~~	13.85	57.71	13.28	55.33	12.72	53.01	12.04	50.18
MAR 14	13.92	58.00	13.37	55.71	12.83	53.45	12.17	50.70
~~MAR 15~~	13.97	58.20	13.43	55.97	12.90	53.75	12.27	51.14
MAR 16	14.07	58.63	13.47	56.14	12.95	53.97	12.36	51.49
~~MAR 17~~	14.20	59.17	13.59	56.63	13.05	54.36	12.42	51.77
MAR 18	14.33	59.69	13.70	57.09	13.14	54.74	12.52	52.15
~~MAR 19~~	14.41	60.05	13.82	57.58	13.26	55.24	12.61	52.53
MAR 20	14.47	60.30	13.90	57.90	13.35	55.64	12.70	52.94
~~MAR 21~~	14.60	60.84	13.97	58.20	13.42	55.91	12.80	53.35
MAR 22	14.76	61.49	14.09	58.70	13.53	56.37	12.88	53.67
~~MAR 23~~	14.87	61.96	14.17	59.03	13.62	56.77	12.98	54.10

DAY OF THE YEAR	GREATER THAN 1.5x 10EXP-6 HOURS	GREATER THAN 1.5x 10EXP-6 TIME 0/0	GREATER THAN 1.5x10EXP-5 HOURS	GREATER THAN 1.5x10EXP-5 TIME 0/0	GREATER THAN 1.5x10EXP-4 HOURS	GREATER THAN 1.5x10EXP-4 TIME 0/0	GREATER THAN 1.5x 10EXP-3 HOURS	GREATER THAN 1.5x 10EXP-3 TIME 0/0
MAR 24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 26	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAR 27	24.00	100.00	24.00	100.00	24.00	100.00	22.46	93.57
MAR 28	24.00	100.00	23.92	99.65	22.87	95.29	19.99	83.30
MAR 29	22.71	94.64	22.25	92.70	21.13	88.05	16.20	67.49
MAR 30	21.39	89.14	20.82	86.77	19.17	79.90	16.21	67.55
MAR 31	19.87	82.79	19.16	79.83	17.95	74.77	16.25	67.69
APR 1	18.74	78.10	18.68	77.83	17.74	73.90	16.40	68.32
APR 2	18.74	78.10	18.68	77.84	17.88	74.49	16.53	68.89
APR 3	19.24	80.17	19.17	79.87	18.02	75.10	16.63	69.31
APR 4	19.24	80.18	19.17	79.89	18.14	75.59	16.71	69.61
APR 5	19.24	80.18	19.18	79.91	18 [illegible]	75.99	16.79	69.96
APR 6	19.49	81.22	19.43	80.94	[illegible]	76.70	16.96	70.67

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	GREATER THAN 1.5x10EXP-2 TIME 0/0	GREATER THAN 1.5x10EXP-1 HOURS	GREATER THAN 1.5x10EXP-1 TIME 0/0	GREATER THAN 1.5x10EXP+0 HOURS	GREATER THAN 1.5x10EXP+0 TIME 0/0	GREATER THAN 1.5x10EXP+1 HOURS	GREATER THAN 1.5x10EXP+1 TIME 0/0
MAR 24	14.93	62.22	14.25	59.38	13.69	57.04	13.08	54.51
MAR 25	15.04	62.68	14.35	59.79	13.79	57.44	13.16	54.82
MAR 26	15.11	62.97	14.46	60.24	13.87	57.80	13.23	55.14
MAR 27	15.17	63.21	14.58	60.74	14.01	58.36	13.33	55.53
MAR 28	15.22	63.42	14.66	61.08	14.11	58.78	13.45	56.03
MAR 29	15.31	63.78	14.71	61.30	14.18	59.07	13.55	56.46
MAR 30	15.46	64.41	14.78	61.60	14.23	59.27	13.63	56.80
MAR 31	15.58	64.90	14.94	62.25	14.32	59.67	13.70	57.07
APR 1	15.65	65.25	15.07	62.78	14.48	60.33	13.76	57.33
APR 2	15.72	65.49	15.15	63.13	14.59	60.77	13.90	57.91
APR 3	15.80	65.83	15.21	63.37	14.66	61.09	14.01	58.38
APR 4	15.97	66.54	15.25	63.55	14.71	61.31	14.10	58.75
APR 5	16.09	67.02	15.42	64.27	14.78	61.60	14.17	59.04
APR 6	16.17	67.36	15.55	64.81	14.94	62.25	14.23	59.29

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-5 HOURS	TIME 0/0	GREATER THAN 1.5x 10EXP-4 HOURS	TIME 0/0	GREATER THAN 1.5x10EXP-3 HOURS	TIME 0/0
APR 7	19.74	82.26	19.67	81.97	18.55	77.31	17.08	71.18
~~APR 8~~	19.74	82.26	19.68	81.99	18.67	77.81	17.17	71.56
APR 9	19.99	83.30	19.92	83.02	18.81	78.37	17.26	71.94
~~APR 10~~	20.24	84.34	20.17	84.05	18.96	79.00	17.40	72.49
APR 11	20.24	84.34	20.18	84.07	19.12	79.69	17.54	73.09
APR 12	21.13	88.04	20.44	85.16	19.30	80.41	17.65	73.54
APR 13	23.13	96.36	21.84	90.99	19.83	82.61	17.76	74.01
APR 14	24.00	100.00	24.00	100.00	20.54	85.58	17.95	74.78
APR 15	24.00	100.00	24.00	100.00	23.20	96.66	18.16	75.66
APR 16	24.00	100.00	24.00	100.00	24.00	100.00	18.57	77.37
APR 17	24.00	100.00	24.00	100.00	24.00	100.00	20.03	83.45
APR 18	24.00	100.00	24.00	100.00	24.00	100.00	21.82	90.90
APR 19	24.00	100.00	24.00	100.00	24.00	100.00	23.34	97.23
APR 20	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
APR 7	16.22	67.60	15.64	65.18	15.06	62.75	14.34	59.75
~~APR 8~~	16.34	68.07	15.70	65.43	15.14	63.09	14.47	60.28
APR 9	16.49	68.72	15.79	65.80	15.20	63.34	14.56	60.69
~~APR 10~~	16.60	69.18	15.91	66.30	15.30	63.78	14.64	61.01
APR 11	16.68	69.51	16.05	66.86	15.40	64.18	14.71	61.29
~~APR 12~~	16.79	69.94	16.14	67.24	15.53	64.71	14.82	61.74
APR 13	16.89	70.37	16.20	67.51	15.62	65.09	14.91	62.14
APR 14	17.04	70.98	16.33	68.03	15.69	65.38	15.02	62.60
APR 15	17.14	71.42	16.42	68.40	15.80	65.83	15.11	62.95
~~APR 16~~	17.25	71.86	16.55	68.96	15.89	66.23	15.19	63.29
APR 17	17.37	72.37	16.64	69.34	16.00	66.68	15.30	63.74
~~APR 18~~	17.52	73.01	16.75	69.79	16.10	67.10	15.38	64.09
APR 19	17.65	73.52	16.86	70.26	16.19	67.46	15.48	64.49
~~APR 20~~	17.76	73.99	16.94	70.60	16.31	67.97	15.57	64.89

DAY OF THE YEAR		GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
		HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O	HOURS	TIME O/O
APR	21	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	22	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	23	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	24	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	25	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
APR	26	24.00	100.00	24.00	100.00	24.00	100.00	19.87	82.79
APR	27	24.00	100.00	24.00	100.00	24.00	100.00	19.76	82.33
APR	28	24.00	100.00	24.00	100.00	23.44	97.66	19.84	82.66
APR	29	24.00	100.00	24.00	100.00	24.00	100.00	19.95	83.12
APR	30	24.00	100.00	24.00	100.00	24.00	100.00	20.12	83.82
MAY	1	24.00	100.00	24.00	100.00	24.00	100.00	20.31	84.62
MAY	2	24.00	100.00	24.00	100.00	24.00	100.00	20.45	85.22
MAY	3	24.00	100.00	24.00	100.00	24.00	100.00	20.65	86.02
MAY	4	24.00	100.00	24.00	100.00	24.00	100.00	20.85	86.86

		GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
APR	21	17.9[illegible]	74.58	17.07	71.12	16.40	68.33	15.66	65.25
APR	22	18.[illegible]	75.21	17.16	71.51	16.48	68.69	15.77	65.73
APR	23	18.14	75.59	17.30	72.09	16.59	69.13	15.86	66.09
APR	24	18.25	76.02	17.40	72.48	16.70	69.59	15.93	66.39
APR	25	18.33	76.39	17.47	72.80	16.82	70.08	16.04	66.81
APR	26	18.42	76.75	17.59	73.29	16.90	70.43	16.13	67.20
APR	27	18.5[illegible]	77.10	17.73	73.86	16.98	70.74	16.24	67.66
APR	28	18.6[illegible]	77.74	17.85	74.35	17.08	71.19	16.34	68.07
APR	29	18.8[illegible]	78.30	17.93	74.71	17.21	71.73	16.41	68.39
APR	30	18.91	78.80	18.03	75.12	17.33	72.19	16.49	68.73
MAY	1	19.[illegible]	79.27	18.15	75.64	17.41	72.54	16.59	69.12
MAY	2	19.1[illegible]	[illegible].91	18.29	76.23	17.48	72.83	16.71	69.52
MAY	3	19.32	[illegible].52	18.39	76.64	17.59	73.28	16.81	70.03
MAY	4	19.4[illegible]	80.97	18.47	76.95	17.73	73.86	16.89	70.37

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6		GREATER THAN 1.5x10EXP-5		GREATER THAN 1.5x10EXP-4		GREATER THAN 1.5x10EXP-3	
	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0	HOURS	TIME 0/0
MAY 5	24.00	100.00	24.00	100.00	24.00	100.00	21.02	87.58
MAY 6	24.00	100.00	24.00	100.00	24.00	100.00	21.25	88.55
MAY 7	24.00	100.00	24.00	100.00	24.00	100.00	21.45	89.36
MAY 8	24.00	100.00	24.00	100.00	24.00	100.00	21.70	90.44
MAY 9	24.00	100.00	24.00	100.00	24.00	100.00	21.95	91.44
MAY 10	24.00	100.00	24.00	100.00	24.00	100.00	22.26	92.76
MAY 11	24.00	100.00	24.00	100.00	24.00	100.00	22.59	94.11
MAY 12	24.00	100.00	24.00	100.00	24.00	100.00	23.06	96.10
MAY 13	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 14	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 15	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 16	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 17	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 18	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2		GREATER THAN 1.5x10EXP-1		GREATER THAN 1.5x10EXP+0		GREATER THAN 1.5x10EXP+1	
MAY 5	19.56	81.50	18.59	77.46	17.84	74.31	16.96	70.65
MAY 6	19.73	82.21	18.75	78.11	17.92	74.65	17.05	71.05
MAY 7	19.87	82.79	18.86	78.59	17.99	74.97	17.16	71.51
MAY 8	19.98	83.25	18.95	78.94	18.10	75.42	17.27	71.95
MAY 9	20.15	83.94	19.06	79.41	18.24	76.00	17.35	72.30
MAY 10	20.32	84.65	19.21	80.03	18.34	76.43	17.43	72.60
MAY 11	20.44	85.16	19.33	80.55	18.42	76.76	17.51	72.95
MAY 12	20.59	85.80	19.43	80.95	18.51	77.12	17.60	73.33
MAY 13	20.79	86.60	19.54	81.42	18.62	77.57	17.71	73.80
MAY 14	20.93	87.21	19.68	82.00	18.75	78.11	17.80	74.19
MAY 15	21.11	87.96	19.81	82.56	18.85	78.53	17.88	74.50
MAY 16	21.32	88.84	19.92	82.98	18.93	78.86	17.95	74.79
MAY 17	21.52	89.67	20.04	83.50	19.02	79.27	18.04	75.18
MAY 18	21.75	90.62	20.17	84.04	19.12	79.67	18.13	75.54

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-6 HOURS	GREATER THAN 1.5x10EXP-6 TIME O/O	GREATER THAN 1.5x10EXP-5 HOURS	GREATER THAN 1.5x10EXP-5 TIME O/O	GREATER THAN 1.5x10EXP-4 HOURS	GREATER THAN 1.5x10EXP-4 TIME O/O	GREATER THAN 1.5x10EXP-3 HOURS	GREATER THAN 1.5x10EXP-3 TIME O/O
MAY 19	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00
MAY 20	24.00	100.00	24.00	100.00	24.00	100.00	24.00	100.00

DAY OF THE YEAR	GREATER THAN 1.5x10EXP-2 HOURS	GREATER THAN 1.5x10EXP-2 TIME O/O	GREATER THAN 1.5x10EXP-1 HOURS	GREATER THAN 1.5x10EXP-1 TIME O/O	GREATER THAN 1.5x10EXP+0 HOURS	GREATER THAN 1.5x10EXP+0 TIME O/O	GREATER THAN 1.5x10EXP+1 HOURS	GREATER THAN 1.5x10EXP+1 TIME O/O
MAY 19	21.99	91.64	20.31	84.62	19.25	80.19	18.23	75.95
MAY 20	22.25	92.72	20.42	85.07	19.34	80.60	18.31	76.31

PART 8: COMPUTATIONS FOR THE MC 'S AND SUN'S POSITIONS IN THE SKY

The useful illumination* provided by the moon on a point on the surface of the earth is determined by the phase of the moon, the zenith distance of the moon, and the zenith distance of the sun. These three quantities vary with time according to the motions of the sun and moon on the celestial sphere with respect to the zenith. Their paths in the sky are defined by the relative positions of their orbits, their positions in their orbits, and the rates of change of position along their orbits. The motion of the observer's zenith is governed by the earth's rotation.

The moon moves, and the sun can be considered to move in nearly circular orbits around the earth. The orbits are inclined to the equator and the nodes, their intersections with the celestial equator, move at essentially a constant rate along the equator with respect to the fixed stars. The rotation of the earth will display to different observers at different geographical longitudes but the same latitude, different relative positions of the sun and the moon with respect to the zenith because of the relative motion of the sun and moon in the time elapsed to bring them from the sky of one observer to the other's.

*This section specifically ignores refraction and absorption.

DEFINITIONS

The desired quantities are:

φ = Phase of the moon

Z_m = Zenith distance of the moon

Z_s = Zenith distance of the sun

The parameters chosen to specify these quantities are:

t = Time

λ = Observer's latitude

ℓ = Observer's longitude

Constants for the orbits (see Fig. 18) are:

i_1 = Inclination of the sun's "orbit" (the ecliptic) to the equator. This was equal to 23° 26' 40" in 1960.

i_2 = Inclination of the moon's orbit to the ecliptic (varying with time from 4° 59' to 5° 18'); the mean value of 5° 8' is taken here.

Variables defining the important motions are (from Fig. 18):

σ = Longitude of the sun from the vernal equinox (♈); i.e., from the ascending node of the sun's orbit with the equator.

μ = Longitude of the moon from the ascending node of its orbit with the ecliptic.

ν = Longitude of the ascending node of the moon's orbit from ♈.

α = Right ascension of the observer's zenith from ♈.

Assuming circular orbits, these variables change uniformly with time:

$$\sigma = \sigma_o + 2\pi\ (t-t_o)/T_s$$

$$\mu = \mu_o + 2\pi\ (t-t_o)/T_m$$

$$\nu = \nu_o - 2\pi\ (t-t_o)/T_n$$

$$\alpha_z = \ell + 2\pi\ (t-t_o)/T_d$$

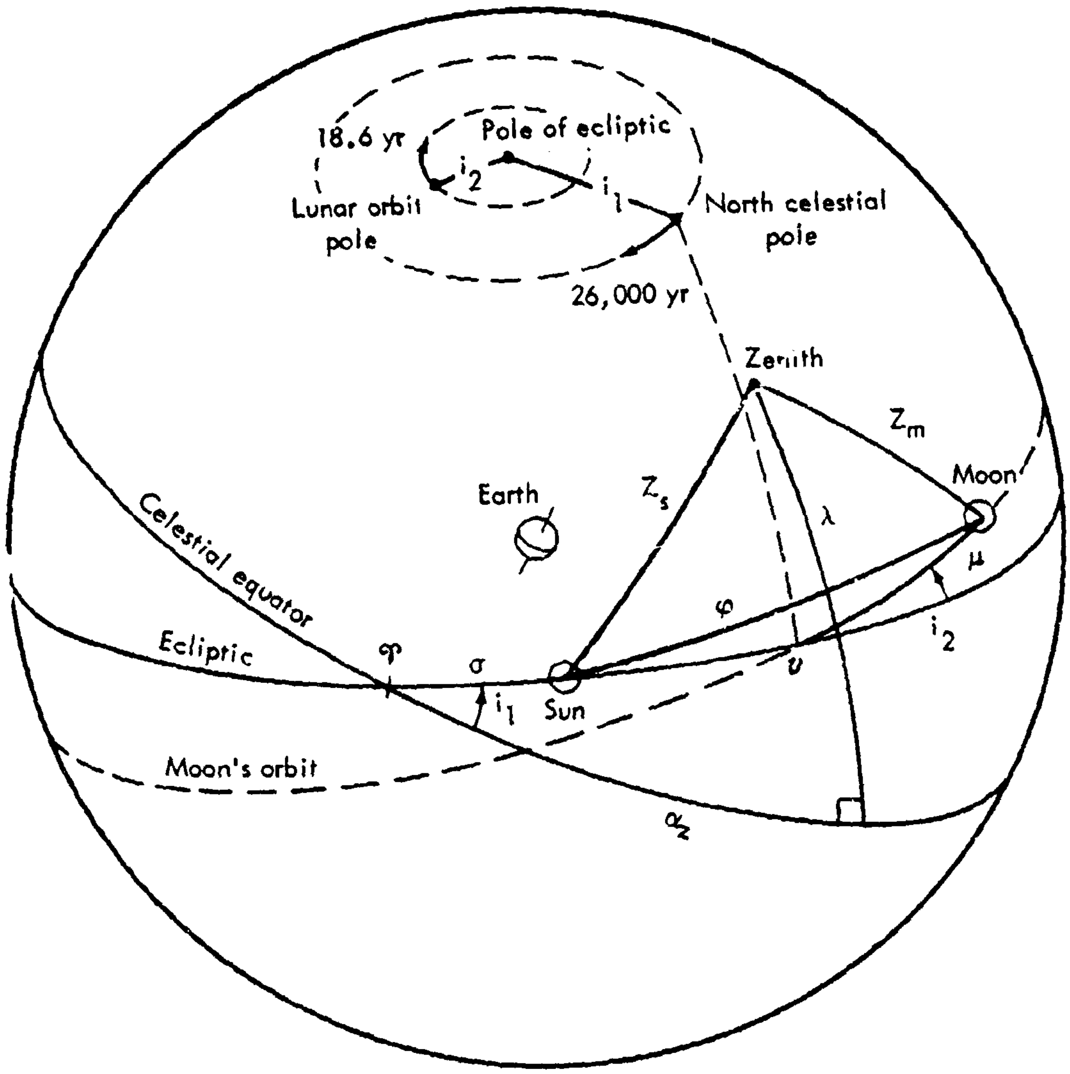

FIGURE 18 Celestial Sphere Showing Lunar Phase φ and Zenith Distances of Sun and Moon

For zero values of σ_o, μ_o, ν_o, and ℓ, zero time ($t=t_o$) corresponds to noon at the Greenwich meridian on March 21, with a new moon and the maximum inclination of the lunar orbit. For the solar eclipse on May 20, 1966, at Greenwich ($\ell = 0$),

$$\sigma_o = 58.84°$$

$$\mu_o = 0$$

$$\nu_o = \sigma_o$$

$$t_o = 7{:}50 \text{ a.m.}$$

The values of the periods are:

T_s = The tropical (civil) year, the time between two successive passages of the sun through the vernal equinox,

$= 3.155692598 \times 10^7$ sec

T_m = The nodical month, the time between two successive passages of the moon through the same node,

$= 2.3511358 \times 10^6$ sec

T_n = The period of regression of the nodes, the time for one revolution of the lunar orbit pole around the pole of the ecliptic,

$= 5.8696 \times 10^8$ sec

= 18.6000 tropical years

T_d = The sidereal day, the time between two successive passages of a fixed star through the meridian,

$= 8.6164099 \times 10^4$ sec

The rate of precession of the celestial pole around the pole of the ecliptic is presently one revolution in 25,781 years and is neglected in our calculations. The assumptions of circular orbits for the sun (eccentricity e = 0.016739) and for the moon (e = 0.05490) leads to maximum errors in their positions of 1.9 - 3.8 deg and 6.3 - 12.6 deg respectively, depending upon the position in the elliptical orbit at which the circular approximation is started.

Three interesting harmonicisms exist between the moon and the sun, with periods all between 18 and 19 years. These are the following:

<u>Saros</u>: The period of recurrence of eclipses = 18 years, 11-1/3 days;

223 synodic months (from conjunction to conjunction) = 6585.32d

19 eclipse years (time for sun to pass from a lunar-orbit node to the same node again = 346.62d) = 6585.78d

239 anomalistic months (from perigee to perigee) = 6585.54d

Metonic Cycle: The period of recurrence of the phases of the moon on the same day of the month;

235 synodic months	= 6939.69d
19 Julian years (365.25d)	= 6939.75d

Period of Regression of Nodes: 18.6000 yr = 6793.5d

DESCRIPTION OF CALCULATIONS

I. Declination and right ascension of the sun are found with the following equations:

$$\delta_s = \sin^{-1} (\sin \sigma \sin i_1)$$

$$\sin \alpha_s = \frac{\sin \sigma \cos i_1}{\cos \delta_s}$$

$$\cos \alpha_s = \frac{\cos \sigma}{\cos \delta_s}$$

The signs of $\sin \alpha_s$ and $\cos \alpha_s$ will give the proper quadrant for the angle α_s.

II. The following equations are used in the computation of the declination of the ascending node:

$$\delta_n = \sin^{-1} (\sin \nu \sin i_1)$$

$$\sin \alpha_n = \frac{\sin \nu \cos i_1}{\cos \delta_n}$$

$$\cos \alpha_n = \frac{\cos \nu}{\cos \delta_n}$$

III. The azimuth of the vernal equinox from the ascending node, the angle AZ_n, is found from the following equations:

$$\sin AZ_n = \frac{\cos i_1}{\cos \delta_n}$$

$$\cos AZ_n = \frac{-\cos \nu \sin \delta_n}{\sin \nu \cos \delta_n}$$

The angle used in the computations of the coordinates of the moon is the angle AZ_m, i.e., the azimuth of the moon from the ascending node:

$$AZ_m = AZ_n - \pi - i_2, \text{ when } \alpha_n \text{ is positive.}$$

$$AZ_m = AZ_n - i_2. \quad \text{when } \alpha_n \text{ is negative.}$$

IV. The moon's right ascension and declination are found with these equations:

$$\delta_m = \sin^{-1} (\sin \delta_n \cos \mu + \cos \delta_n \sin \mu \cos AZ_m)$$

$$\alpha_m = \alpha_{mn} + \alpha_n$$

$$\sin \alpha_{mn} = \frac{\sin AZ_m \sin \mu}{\cos \delta_m}$$

$$\cos \alpha_{mn} = \frac{\cos \mu - \sin \delta_n \sin \delta_m}{\cos \delta_n \cos \delta_m}$$

V. The coordinates of the zenith are as follows:

$$\delta_z = \text{Latitude of Observer, } \lambda$$

$$\alpha_z = \ell + \frac{2 \pi t}{T_d}$$

VI. The zenith distance of the moon, Z_m, is found from:

$$Z_m = \cos^{-1} \left(\sin \delta_s \sin \delta_z + \cos \delta_s \cos \delta_z \cos (\alpha_z - \alpha_s)\right)$$

The zenith distance of the sun, Z_s, is found from:

$$Z_s = \cos^{-1} \left(\sin \delta_m \sin \delta_z + \cos \delta_m \cos \delta_z \cos (\alpha_m - \alpha_z)\right)$$

The great circle distance from the sun to the moon, φ, is found from:

$$\varphi = \cos^{-1} \left(\sin \delta_s \sin \delta_m + \cos \delta_s \cos \delta_m \cos (\alpha_m - \alpha_s)\right)$$

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APPENDIX

Natural Illumination Charts

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NATURAL ILLUMINATION CHARTS

RESEARCH AND DEVELOPMENT

Project NS 714-100

(September 1952)

DEPARTMENT OF THE NAVY

BUREAU OF SHIPS

WASHINGTON 25, D. C.

INTRODUCTION

It is the purpose of these charts to provide the Armed Forces with convenient and rapid access to the latest scientific information available on natural illumination. For clear days and clear moonless nights, the illumination in foot-candles falling on a fully exposed horizontal plane at any point on the earth, at any day of the year, and at any hour of the day or night, can be found quickly and simply. This information is of prime importance in answering questions relating to reconnaissance, visibility, concealment, and other naval and military problems. Because of the confidential nature of many of the problems, illustrations and examples of the use of this material are to be published under separate cover.

Derivation of Basic Curve and Table. More than 12,000 measurements were made by the author in the Arctic, Antarctic, and the temperate and torrid zones of both hemispheres between January 1943 and May 1947. Photoelectric illuminometers manufactured by the General Electric Company were used for the measurement of light levels above one foot candle. Lower levels were measured by means of a Luckiesh-Taylor Brightness Meter and a calibrated test plate. The illuminometers were calibrated by the U.S. Bureau of Standards before and after the measurements were made. The brightness photometers were calibrated by the Nela Park Laboratory of the General Electric Company.

The original data were plotted at large scale and a smooth curve was drawn. This basic curve was found to be in good agreement with fractional curves published in the scientific literature by Jones and Condit* and others.

The first plate (unnumbered) is the basic curve which gives the illumination as a function of solar altitude. The second plate (also unnumbered) is a table of illumination values corresponding to each degree of altitude of sun from - 90 to - 21 degrees and from 65 to 90 degrees. Illumination values are given for each tenth of degree of solar altitude from - 20 to 64 degrees. In most cases, the figures given are representative of the precision indicated; however, in the lowest levels of illumination, below 5×10^{-6} (when the sun is 19.5 degrees or more below the horizon), three significant figures are not justified by the data. Likewise, above 1000-foot candles (9.9 degrees solar altitude and above) the value of illumination is considered significant to no more than three figures although four are occasionally given

*Lloyd A. Jones and H.R. Condit, J. Opt. Soc. AM. 38, 139,(1948)

EQUATION of TIME

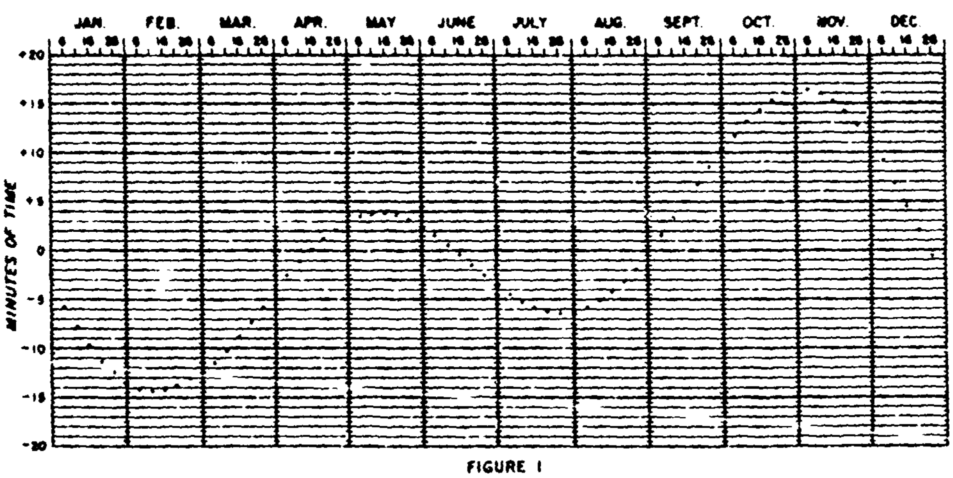

FIGURE 1

in the table. Actually, the values given in the table were taken from a minute reading of the basic curve, greatly enlarged in scale, and present a truer picture of the curve than could be made by straight interpolation of the table had only two or three figures been given.

Plates 1 to 17, inclusive - Latitude Series. Each plate in this series applies to a given latitude as shown in the large figure at the top of the plate. Each plate contains a family of curves, each curve representing a given day of any year when the declination of the sun is as indicated on the curve. In this "Latitude Series" the illumination is plotted continuously as a function of time from midnight to noon and applies conversely from noon to midnight as indicated on the time scale. Plates were constructed after tabulating 33,500 solar altitude values and 33,500 corresponding values of the illumination. These values were plotted for each 20 minutes of time and curves drawn through. After careful check of the plotted points, the final curves and inking were accomplished by Mr. Henry Everett of Washington, D.C.

Inspection of the latitude series clearly illustrates the sameness of the light at the equator day after day, throughout the year: sameness both as to time of occurrence and to range of intensity. As one progresses away from the equator into the lower latitudes of the temperate zones, the most significant change from day to day is seen to be in the time of occurrence of the normal light distribution for that latitude. However, as one leaves the tropics a perceptible rise and fall in the noon intensity is found to occur from day to day. This becomes progressively more noticeable all the way to the Poles. The rate of change from starlight to a dazzling light in the early morning at the equator is contrasted in this series with the very slow changes which occur in any one calendar day in the polar regions. Other characteristics of illumination peculiar to latitude can be noted.

Plates 18-43 - Declination Series. Each pair of these charts is for a certain day of the year as indicated by the declination at the top of the page. The illumination is shown as a continuous function of latitude, each curve representing a given hour of the day. This series of curves, which derive from the same data previously described, is presented in this second form primarily to allow direct reading of illumination values at any latitude from one pole to the other for a series of days throughout the year.

Declination and Time. The approximate declination may be obtained from the graph here illustrated for a mean year (Figure 2). More accurate declinations are given in nautical almanacs. The same holds true for the equation of time. All hours given are for Local Apparent Time, sometimes called True Sun Time. Conversion of clock or standard time to Local Apparent Time is made as follows:

To standard time, add equation of time, algebraically (add using sign given). To this total add 4 minutes for each degree your location may be East of the meridian of the time zone in which you are located. (Time zone meridians are spaced every 15 degrees from Greenwich). Or subtract 4 minutes for every degree your location may be West of the zone meridian. In case you are on Daylight Saving Time, you will subtract another hour to obtain local apparent time. Example: Assume you wish the true sun time (local apparent time) for a place 73 degrees West Longitude on June 3, when Eastern Standard Time according to your watch is 13:45.

Standard Time 13:45

Equation of Time for June 3 . . . . . . +00:02

Total (true sun time at zone meridian) . 13:47

75 degrees minus 73 degrees equals 2

DECLINATION of SUN

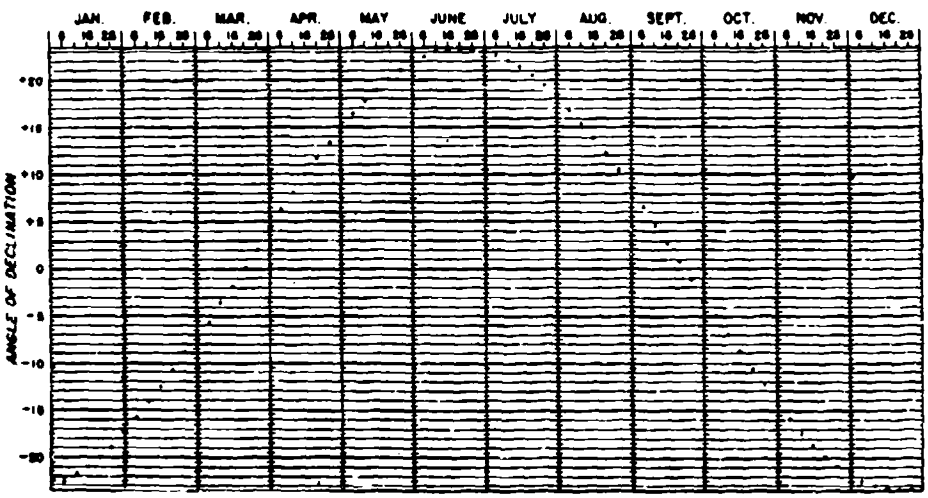

FIGURE 2

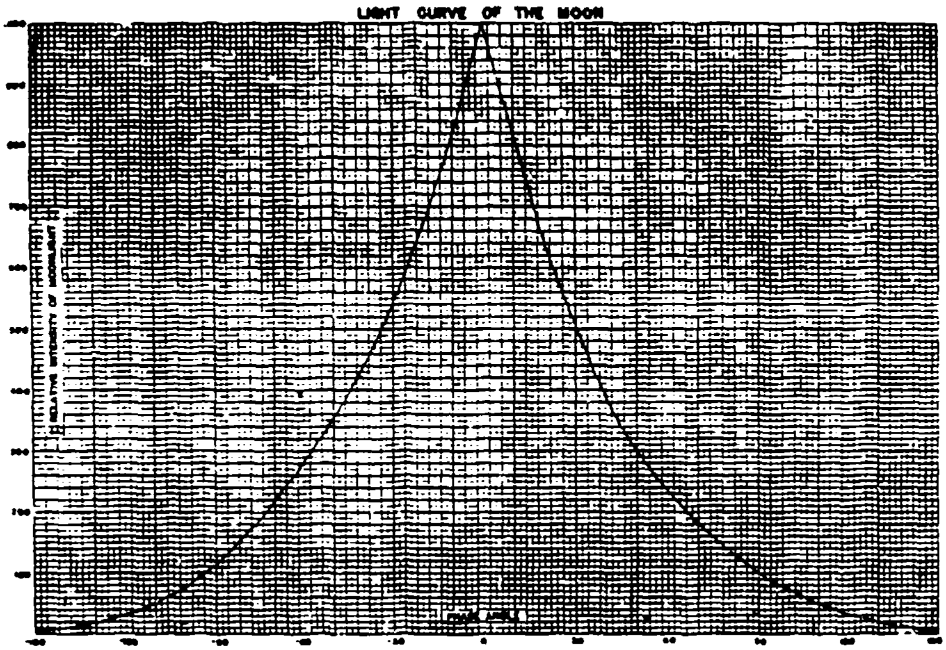

FIGURE 3

degrees (no. of degrees east of meridian)

2 degrees multiplied by 4 minutes per degree equals + 00:08

True Sun Time (Local Apparent Time). 13:55

Clear vs. Cloudy Conditions. The charts and tables contained herein, refer to light conditions during average clear days, clear days being defined as less than seven tenths overcast and with the sun's rays unobstructed to the locality in question. When the sun is obstructed by thin clouds, the values given should be divided by two. For average cloud conditions obstructing the sun's rays, the values given for clear days should be divided by three. Occasionally, for dark stratus clouds preceding a heavy thunder storm, the values given should be divided by ten. However, this is not common.

Influence of the Moon. The illumination due to the moon may be estimated roughly from its altitude and phase in the following manner. When the altitude of a full moon is 65 degrees on a clear night, the illumination on a horizontal plane is approximately 0.03 foot-candles. When the sun's altitude is 65 degrees, the illumination on a horizontal plane is 10,000 foot-candles. The ratio of full moonlight to sun plus sky-light is then roughly 3 to 1,000,000. Other values for full moonlight follow the same proportion.

Therefore, to estimate the illumination on a clear night with a full moon, determine the altitude of the moon and look up the value of the illumination due to sun plus skylight (for the same altitude) in the basic solar altitude-illumination curve and multiply this value by three-millionths (3×10^{-6}).

When the moon is not full, this value must be multiplied by a factor obtained from figure 3* which gives the relative intensity of the moon's illumination as a function of phase angle. Determine the phase angle by observation or preferably from the Nautical Almanac and from the graph (figure 3) obtain the relative intensity of the illumination. Divide this number by 1000 and multiply the value of the illumination for full moonlight (obtained as in the preceding paragraph) by the result.

It is the hope of the author that these charts and tables may prove of value to oceanographers, meteorologists, photographers, agriculturalists, and other scientists as well as to naval and military personnel.

Dayton R.E. Brown

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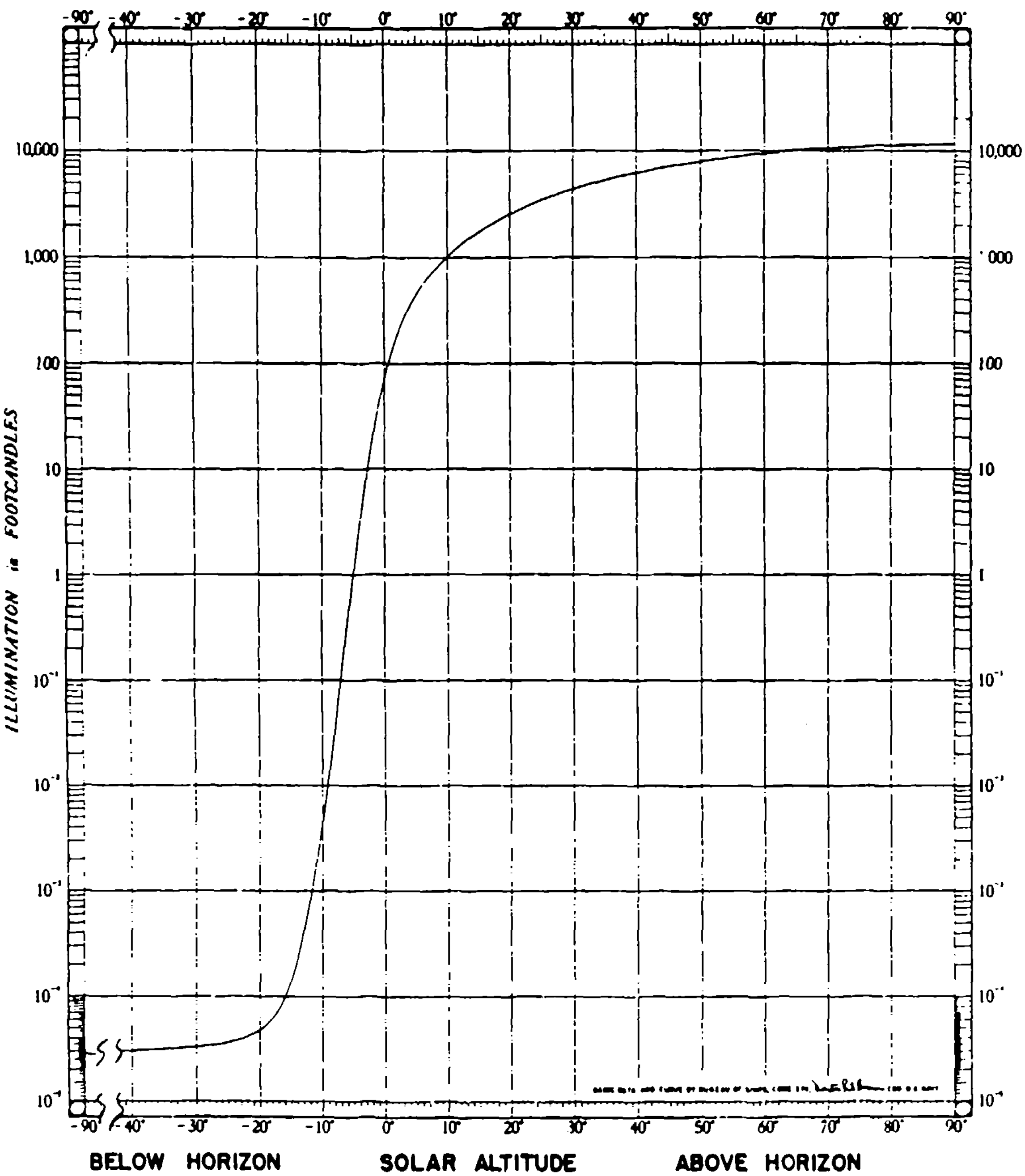
COMMANDER U.S. NAVY

*H.N. Russel, Astrophysical J., 43, 117 (1916)

BASIC CURVE

ILLUMINATION IN FOOTCANDLES CORRESPONDING TO SUN'S ALTITUDE



INTRODUCTION

It is the purpose of this book to provide the Armed Forces with convenient and rapid access to scientific information available on natural illumination. For clear days and clear moonless nights, the average illumination in footcandles falling on a fully exposed horizontal plane at any point on the earth, at any day of the year, and at any hour of the day or night, can be found quickly and simply. This information is of prime importance in answering questions relating to visibility, optical search, detection, reconnaissance, concealment, and other naval and military problems.

Natural illumination exerts a great influence on the existence of all living things — plants, fishes, birds, and animals — including the lives and habits of men. It is hoped, therefore, that these charts and tables may prove of value to men of science, agriculture, and industry as well as to naval and military personnel.

DERIVATION OF BASIC ILLUMINATION CURVE AND TABLE

More than 12,000 illumination measurements were made by the author, or under his supervision, in the Arctic, Antarctic, and the temperate and torrid zones of both hemispheres between January 1943 and May 1947. Photoelectric illuminometers manufactured by the General Electric Company were used for the measurement of light levels above 1 fc. Lower levels were measured by means of brightness photometers and a calibrated test plate. The G. E. Illuminometers and the Brien O'Brian low-level Brightness Photometers used were calibrated by the U. S. Bureau of Standards before and after the measurements were made. The Luckiesh-Taylor Brightness Photometers were calibrated by the Nela Park Laboratory of the General Electric Company.

The original data were plotted on large scale and a smooth curve was drawn. This basic curve was found to be in good agreement with fractional curves published in the scientific literature by Jones and Condit[1] and others.

The basic curve (fig. 1) gives the average illumination falling on a fully exposed horizontal plane in air at sea level, as a function of the sun's altitude. The average values from which the basic curve was constructed were based upon a great number of so-called perfectly clear days which, of necessity, could not be defined in precise terms as to their light-absorption and light-scattering properties. Consequently the basic curve is based upon data which had variations of probably five to ten percent due to differences in the atmosphere alone. Likewise the G. E. illuminometers and photometers used contain certain limitations, so that the meter readings cannot be considered more accurate than two significant figures. Against this it should be noted that the basic curve itself smoothed out much of the inaccuracy arising from the two factors just mentioned and also the final curves provided a basis for additional corrections. The resultant basic curve, as presented, is considered to be a reasonably accurate statement of the light attendant on "clear" conditions. A combination of differences in haze, distance of the earth from the sun, sun spots, and other lesser factors altogether should not make more than a 10 per cent variation from the values plotted on the basic curve. Table 1 gives values of average illumination in footcandles corresponding to points on the basic curve. Values are tabulated for each degree of altitude of sun from $-90°$ to $-21°$ and from 65° to 90°, and for each tenth of a degree from $-20°$ to 64°. In most cases, the values given are representative of the internal precision indicated, however, in the lowest levels of illumination (below 5×10^{-5},* when the sun is 19.5° or more below the horizon) three significant figures are not justified by the data. Likewise, above 1000 fc (9.9° solar altitude and above) the value of illumination is considered significant to no more than three figures, although four are occasionally given in the table. Actually, the values given in the table were taken from a minute reading of the basic curve, greatly enlarged in scale, and present a truer picture of the curve than could be made by straight interpolation of the table had only two or three figures been given.

CONSTRUCTION OF PLATES

Preliminary to drawing the curves on the 43 plates, tables were made of the sun's altitude for every 20 minutes of time, for each 2 degrees of declination from 0 to 23½ degrees inclusive, and for every 5-degree interval of latitude from pole to pole. These calculations and plots were precise to within 6 seconds of time and 6 minutes of arc for solar altitude and 6 minutes of arc for latitude. To the 34,632 values of altitude, corresponding illumination values were tabulated and plotted.** Hence, the curves appearing in the plates are a more precise index of solar altitude as a function of time and place than they are for illumination attendant on those altitudes. It follows that, whether or not we accept the precision of light values finally assigned to the basic curve and to table 1, we can use the illumination curve for a given date, time, and place on any appropriate plate to determine the solar altitude. Or, given a solar altitude at a place, the precise time of occurrence of that solar altitude can be read on any of the appropriate plates. We cannot say, with the same degree of precision, that for a given time and place the illumination will be such and such.

[1] L. A. Jones and H. R. Condit "Sunlight and Skylight as Determinants of Photographic Exposure. I — Luminous Density as Determined by Solar Altitude and Atmospheric Conditions", *Optical Society of America. Journal* vol. 38, no. 2, February 1948, p. 139.

* For the convenience of those not familiar with the convention of negative powers, we include a brief explanation: 5×10^{-5} means $5 \times 1/(10)^5$, or $5 \times 1/100{,}000$, or 0.00005; likewise, 2×10^{-2} equals 0.02. The list of equivalent values below should prove helpful.

$1 \times 10^{0} = 1.0$
$1 \times 10^{-1} = 0.1$
$1 \times 10^{-2} = 0.01$
$1 \times 10^{-3} = 0.001$
$1 \times 10^{-4} = 0.0001$
$1 \times 10^{-5} = 0.00001$

** The calculations, tabulations, and plots were done under the direct supervision of Mr. Robert Sandberg. The final curves were drawn and inked by Mr. Henry Everett.

_ ls of time conventions are used in the world today. …unities have no clocks and measure or estimate time b; the sun and stars. Saudi Arabia keeps sun time and sets clocks each day at sundown. Most countries keep one time throughout their domain. In some countries clock time approximates sun time but in other countries there are areas in which clocks differ from the sun time by an hour or more. Since the charts in this book are based on true sun time, some explanation is necessary. In the United States, clock time and sun time can differ as much as two hours, although the average difference is much less.

Briefly, the conversion of clock time to local apparent time in the United States is made as follows:

Standard time plus 4 minutes per degree that a place is east of its zone meridian equals *mean* solar time,

or

Standard time minus 4 minutes per degree that a place is west of its zone meridian equals *mean* solar time.

Mean solar time plus equation of time* equals local apparent time (true sun time).

Daylight saving time (when it is in effect) minus 1 hour equals standard time.

* Equation of time may be either a positive or negative quantity. The quantity should be added algebraically, i.e., using the appropriate sign. (See section titled Equation of Time.)

International Time Zone System

The International Time Zone System is a very regular system is ideal for use at *sea* and in the *air*. Hence it is used by navi-.s and nautical astronomers the world over. This ideal system les the earth's surface into twenty-four zones. Each zone is egrees wide (from east to west) and extends from the North to the South Pole. The north-south center line of each zone lled the international zone meridian of that zone. The Inter-onal Time Zone System, as defined by international agreement, own in table 2.

The fact that there are other kinds of time zones and other zone meridians used on *land* which are *not always* the same ie regular international time zones and meridians used at *sea* leads to some confusion. We shall attempt to clarify this issue.

TABLE 2. International time zones.

Zone: Western Boundary (°Long.)	Zone: Eastern Boundary (°Long.)	Zone Meridian	Hour Designation	Letter Designation
7.5 W	7.5 E	Zero	Zero	Z
7.5 E	22.5	15 E	−1	A
22.5	37.5	30	−2	B
37.5	52.5	45	−3	C
52.5	67.5	60	−4	D
67.5	82.5	75	−5	E
82.5	97.5	90	−6	F
97.5	112.5	105	−7	G
112.5	127.5	120	−8	H
127.5	142.5	135	−9	I
142.5	157.5	150	−10	K
157.5	172.5 E	165 E	−11	L
172.5 E	172.5 W	180	−12 and +12*	M and Y*
172.5 W	157.5 W	165 W	+11	X
157.5	142.5	150	+10	W
142.5	127.5	135	+9	V
127.5	112.5	120	+8	U
112.5	97.5	105	+7	T
97.5	82.5	90	+6	S
82.5	67.5	75	+5	R
67.5	52.5	60	+4	Q
52.5	37.5	45	+3	P
37.5	22.5	30	+2	O
22.5	7.5	15	+1	N

*The major portion of the 180° meridian marks the International Date Line dividing the normal 15° wide zone into two parts both having the same hour but having different dates. West of 180° it will be 0644 hours Tuesday while east of 180° it will be 0644 hours Monday. Each of these semi-zones has a letter designation and an hour designation of its own: the half westward of the 180° meridian is M and −12, the half eastward of the 180° meridian is Y and +12. The number designation in a zone added algebraically to the zone time gives the Greenwich Standard Time (time in zone Z), for example: When it is 0100 hours (1 A.M.) in zone Y on Saturday, 14 August, it is 0100 plus 12 or 1300 hours in the Z zone Saturday, 14 August. At the same instant it is 0100 hours in zone M Sunday, 15 August, then 0100 hours Sunday in zone M minus 12 hours also equals 1300 hours Saturday in Zone Z.

In order to avoid cutting through any land area, the International Date Line, their common boundary, does not always follow the 180° meridian and is, therefore, not entirely regular. Hydrographic Office Chart 5192, although not required reference for use with the Illumination Charts, can be very helpful, because it explains the time zone system and shows the many irregular shapes of the zones throughout the world.

Standard Time

Standard time is the same as international time at sea and in the air because, for purposes of navigation, the two sets of zones and their respective meridians have been made identical. However, other standard time zones are used for land areas or areas containing groups of islands, which are often very irregular in size and shape. As a result of the irregularity, the time-reference meridian selected for a land area is often a meridian other than that designated for the international time zone in which the land area lies. Furthermore, the standard or legal time used in some countries has been based on the legal or standard time of a neighboring country rather than on its own central meridian. In such cases, the standard meridian for a country may lie outside the country altogether.

In the United States there are four standard time areas. Each area, although very irregular in size and shape, uses the international zone meridian for its standard time meridian (fig. 2) and most of each area lies within one of the international zones. The standard time zone meridians in the United States are:

For Eastern Standard Time the standard meridian is 75° W. longitude
For Central Standard Time the standard meridian is 90° W. longitude
For Mountain Standard Time the standard meridian is 105° W. longitude
For Pacific Standard Time the standard meridian is 120° W. longitude

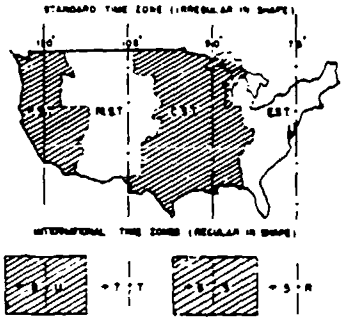


Figure 2. Time zones.

Since the U.S. standard time meridians are 15 degrees apart, the sun crosses successive meridians on successive hours. That is, the sun reaches its high-noon position at one meridian after another, taking 60 minutes of time to get from one standard zone meridian to the next one to westward. Hence, all of the clocks in the Central Standard Time area will read, say 5, while the clocks in the Eastern Standard Time area read 6 (one hour more), and the clocks in the Mountain Standard Time area read 4 (one hour less).

Correction for Longitude

Many of the standard time zones of the world, including three of the four in the United States, are more than 15° wide, so that it takes the sun over an hour to cross each of these zones. Since all of the clocks in any one zone or area keep the same time, one can see that only a small percentage of the clocks keep mean sun time. In the U.S. only the clocks on the standard time zone meridians keep mean sun time. On *these particular meridians* international zone time, standard time, and mean sun time are all alike. In each standard time area or zone, clocks to the east are slow, or behind, mean sun time and clocks to the west are fast, or ahead of, mean sun time, because when the sun appears to rise to the people living

on the time zone meridian, it has already been up some time to the people east of the meridian and it will be some time to come before the sun rises for the people who live west of the meridian. For each degree of longitude that a place is east of the zone meridian, the mean solar time is four minutes more than the clock. For each degree a place is west of the zone meridian, the mean solar time is 4 minutes slower than the clock.

For example: Chatham, Massachusetts, and Philadelphia and Pittsburgh, Pennsylvania, all lie in the same standard time zone. Their clocks all keep Eastern Standard Time. The Eastern Standard Time zone meridian is 75° W. longitude. The approximate longitudes of the cities and corresponding times at one given instant when all the clocks read 10, are as follows:

		Clock (EST)	Sun (mean solar time)
Chatham, Mass.	70° W	1000 hours	1020 hours
Philadelphia, Pa.	75° W	1000 hours	1000 hours
Pittsburgh, Pa.	80° W	1000 hours	0940 hours

The 4 minutes of time per degree of longitude comes about in the following way: the rotation of the earth on its polar axis is completed approximately once every 24 hours. The apparent course of the sun around the earth as a whole — not around the horizon, but around the earth — is 360° in 24 hours, which is 15° per hour, or 1° every 4 minutes. Hence the sun travels relatively from east to west across the earth's surface 1° of longitude every 4 minutes of time.

Equation of Time

Clock-time schedules assume that (1) every day starts the moment after midnight, with the sun at its lowest point, (2) the sun moves with perfect regularity around the sky every day of the year, (3) the sun reaches the highest point in the sky at noon each day by the clock, and (4) every day has 24 hours of equal length. Actually, most of these assumptions are not quite true. During the course of a year's time, the sun goes through four phases, two of slowing down and two of speeding up. As a result of this irregularity, the perfect sun time schedule suffers. The tardiness accumulates day after day at one season, so that the true sun is nearly 14 minutes behind its average schedule before it gets back to normal. Then it gets ahead by about four minutes, then behind by six, then ahead again by a bit over 16 minutes. Consequently, a perfectly regular clock, located on one of the time-zone meridians, will keep mean solar time, but this will differ from true solar time by any amount up to 16 minutes during the course of a year.

As stated previously, the average or mean sun schedule gives mean solar time, and most time zones use the mean solar time of the zone meridians for their zone time. To adjust for the irregularity in the sun's schedule, a number of minutes, known as the equation of time, is introduced. By definition, the equation of time is that quantity which, when added algebraically to mean solar time, will give true solar time. This quantity changes from day to day and may be either negative or positive. When the sun is ahead of its average schedule, the equation of time is positive; when the sun is behind its average schedule, the equation of time is negative. Values for a mean year may be read from the appropriate curve in figure 3. Values more precise for any given year and hour may be obtained from the current issue of the American Nautical Almanac compiled and published by the U.S. Naval Observatory, Washington, D.C.

DECLINATION OF SUN AND EQUATION OF TIME

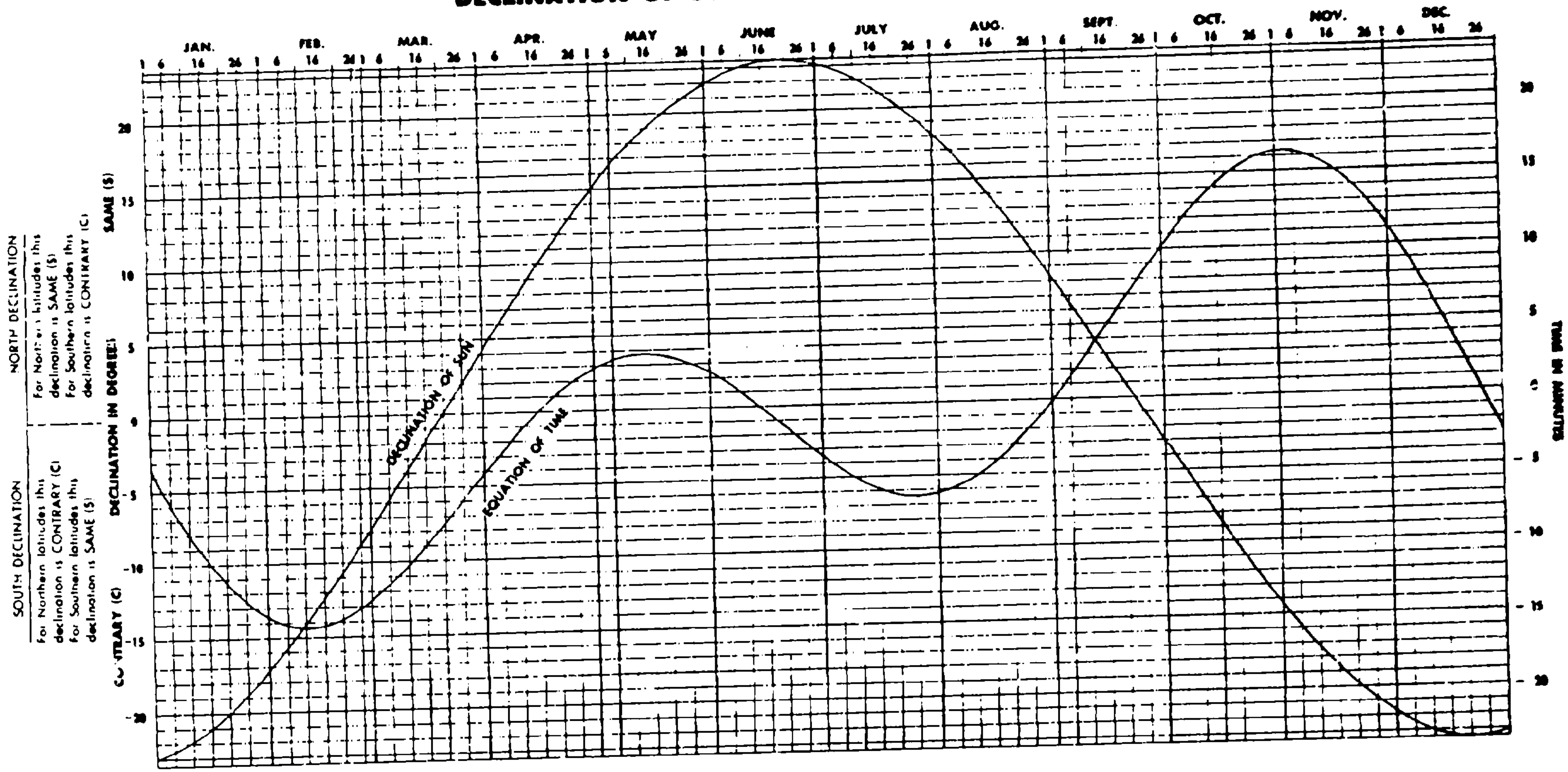


Figure 3. Declination of sun and equation of time.

ILLUMINATION IN FOOTCANDLES
CORRESPONDING TO THE SUN'S ALTITUDE
(angles of solar depression are i[illegible]ated as negative altitudes)

SUN BELOW HORIZON

Altitude	Footcandles
-90°	2.80×10[illegible]
-89°	
-88°	
-87°	
-86°	
-85°	
-84°	
-83°	
-82°	
-81°	
-80°	
-79°	
-78°	2.80×10[illegible]
-77°	2.81×10[illegible]
-76°	
-75°	
-74°	
-73°	
-72°	
-71°	
-70°	2.81×10[illegible]
-69°	282
-68°	283
-67°	
-66°	283
-65°	283
-64°	
-63°	284
-62°	285
-61°	285
-60°	286
-59°	286
-58°	287
-57°	287
-56°	288
-55°	288
-54°	289
-53°	290
-52°	291
-51°	292
-50°	293
-49°	294
-48°	295
-47°	296
-46°	297
-45°	298
-44°	299
-43°	300
-42°	301
-41°	302
-40°	304
-39°	306
-38°	308
-37°	310
-36°	312
-35°	314
-34°	317
-33°	320
-32°	323
-31°	327
-30°	332
-29°	336
-28°	342
-27°	346
-26°	350
-25°	358
-24°	373
-23°	394
-22°	414
-21°	441

Altitude	Footcandles	Altitude	Footcandles
-20°	477×10[illegible]	-10°	430×10[illegible]
9	481	9	473
8	485	8	520
7	490	7	572
6	495	6	632
5	500	5	697
4	505	4	770
3	511	3	850
2	516	2	940
1	522	1	1.04×10[illegible]
-19°	528	-9°	115
9	534	9	126
8	540	8	139
7	546	7	157
6	553	6	174
5	562	5	193
4	570	4	213
3	578	3	237
2	587	2	263
1	595	1	292
-18°	605	-8°	324
9	615	9	362
8	625	8	402
7	636	7	449
6	647	6	500
5	660	5	560
4	673	4	627
3	686	3	701
2	700	2	786
1	715	1	883
-17°	730	-7°	10[illegible]
9	747	9	112
8	765	8	126
7	783	7	141
6	803	6	158
5	825	5	177
4	845	4	198
3	869	3	223
2	895	2	251
1	924	1	281
-16°	957	-6°	315
9	991	9	353
8	1.02×10[illegible]	8	397
7	106	7	447
6	110	6	501
5	114	5	561
4	118	4	630
3	123	3	700
2	128	2	794
1	134	1	890
-15°	140	-5°	1.00
9	146	9	111
8	152	8	124
7	159	7	138
6	167	6	154
5	175	5	172
4	183	4	193
3	192	3	[illegible]
2	202	2	237
1	212	1	260
-14°	224	-4°	291
9	235	9	323
8	248	8	361
7	262	7	398
6	276	6	438
5	292	5	484
4	308	4	534
3	327	3	580
2	347	2	640
1	368	1	710
-13°	392	-3°	780
9	418	9	855
8	444	8	935
7	473	7	102
6	504	6	111
5	540	5	121
4	580	4	131
3	620	3	143
2	665	2	155
1	716	1	167
-12°	772	-2°	180
9	832	9	195
8	900	8	210
7	973	7	227
6	1.05×10[illegible]	6	244
5	114	5	262
4	124	4	282
3	135	3	302
2	146	2	324
1	158	1	348
-11°	174	-1°	370
9	188	9	395
8	203	8	421
7	222	7	447
6	244	6	476
5	268	5	506
4	294	4	538
3	323	3	572
2	355	2	605
-.1	390	-.1	642

SUN ABOVE HORIZON

Alt.	fc	Alt.	fc	Alt.	fc	Alt.	fc	Alt.	fc	Alt.	fc	Alt.	fc
0°	660	10°	1015	20°	2540	30°	4370	40°	6200	50°	7900	60°	9450
1	713	1	1028	1	2555	1	4390	1	6220	1	7920	1	9460
2	760	2	1040	2	2575	2	4410	2	6230	2	7940	2	9470
3	803	3	1053	3	2590	3	4430	3	6250	3	7950	3	9480
4	848	4	1066	4	2610	4	4450	4	6270	4	7970	4	9500
5	893	5	1082	5	2625	5	4460	5	6280	5	7990	5	9510
6	942	6	1095	6	2645	6	4480	6	6300	6	8000	6	9520
7	993	7	1109	7	2660	7	4500	7	6320	7	8020	7	9530
8	104	8	1123	8	2675	8	4520	8	6340	8	8040	8	9540
9	110	9	1136	9	2690	9	4540	9	6350	9	8050	9	9550
1°	115	11°	1150	21°	2705	31°	4560	41°	6370	51°	8070	61°	9570
1	121	1	1162	1	2725	1	4580	1	6390	1	8080	1	9580
2	128	2	1178	2	2745	2	4600	2	6410	2	8100	2	9600
3	134	3	1193	3	2760	3	4620	3	6420	3	8120	3	9610
4	140	4	1205	4	2780	4	4640	4	6440	4	8140	4	9620
5	148	5	1220	5	2795	5	4660	5	6460	5	8150	5	9630
6	155	6	1235	6	2810	6	4680	6	6480	6	8160	6	9640
7	161	7	1250	7	2830	7	4700	7	6490	7	8190	7	9660
8	168	8	1262	8	2845	8	4710	8	6510	8	8210	8	9670
9	175	9	1275	9	2860	9	4730	9	6530	9	8220	9	9680
2°	183	12°	1290	22°	2875	32°	4750	42°	6540	52°	8240	62°	9690
1	191	1	1303	1	2895	1	4770	1	6560	1	8260	1	9700
2	199	2	1318	2	2910	2	4790	2	6580	2	8270	2	9710
3	206	3	1329	3	2930	3	4810	3	6590	3	8290	3	9720
4	215	4	1342	4	2945	4	4830	4	6610	4	8310	4	9730
5	222	5	1356	5	2960	5	4850	5	6630	5	8320	5	9750
6	231	6	1370	6	2980	6	4870	6	6640	6	8340	6	9760
7	239	7	1385	7	3000	7	4880	7	6660	7	8360	7	9770
8	248	8	1400	8	3015	8	4900	8	6670	8	8380	8	9780
9	256	9	1415	9	3035	9	4920	9	6690	9	8390	9	9790
3°	265	13°	1430	23°	3050	33°	4940	43°	6710	53°	8410	63°	9800
1	274	1	1448	1	3070	1	4960	1	6720	1	8430	1	9810
2	282	2	1460	2	3090	2	4980	2	6730	2	8440	2	9820
3	290	3	1475	3	3105	3	4990	3	6760	3	8460	3	9830
4	298	4	1490	4	3125	4	5010	4	6780	4	8480	4	9840
5	307	5	1504	5	3145	5	5030	5	6800	5	8490	5	9850
6	316	6	1518	6	3165	6	5050	6	6810	6	8510	6	9860
7	324	7	1532	7	3180	7	5070	7	6830	7	8530	7	9870
8	333	8	1545	8	3200	8	5080	8	6850	8	8540	8	9880
9	342	9	1560	9	3215	9	5100	9	6870	9	8560	9	9890
4°	350	14°	1575	24°	3230	34°	5120	44°	6880	54°	8580	64°	9900
1	359	1	1590	1	3250	1	5140	1	6900	1	8600	1	9910
2	368	2	1604	2	3265	2	5160	2	6920	2	8610	2	9920
3	377	3	1618	3	3285	3	5170	3	6930	3	8630	3	9930
4	386	4	1635	4	3305	4	5190	4	6950	4	8650	4	9940
5	395	5	1650	5	3320	5	5210	5	6970	5	8670	5	9950
6	404	6	1665	6	3340	6	5230	6	6980	6	8680	6	9960
7	414	7	1680	7	3360	7	5250	7	7000	7	8700	7	9970
8	424	8	1695	8	3380	8	5260	8	7010	8	8710	8	9980
9	433	9	1710	9	3395	9	5280	9	7030	9	8730	9	9990
5°	442	15°	1725	25°	3410	35°	5300	45°	7050	55°	8740	65°	10000
1	452	1	1740	1	3430	1	5320	1	7060	1	8750	66°	10100
2	462	2	1755	2	3460	2	5340	2	7080	2	8770	67°	10200
3	472	3	1770	3	3475	3	5350	3	7100	3	8780	68°	10300
4	482	4	1788	4	3495	4	5370	4	7120	4	8800	69°	10400
5	492	5	1805	5	3510	5	5390	5	7130	5	8820	70°	10480
6	501	6	1820	6	3530	6	5410	6	7150	6	8840	71°	10570
7	512	7	1835	7	3550	7	5420	7	7170	7	8850	72°	10650
8	522	8	1855	8	3570	8	5440	8	7180	8	8860	73°	10720
9	533	9	1870	9	3585	9	5460	9	7200	9	8880	74°	10800
6°	543	16°	1885	26°	3600	36°	5480	46°	7220	56°	8890	75°	10870
1	554	1	1900	1	3620	1	5500	1	7240	1	8900	76°	10930
2	566	2	1915	2	3640	2	5510	2	7250	2	8920	77°	11000
3	577	3	1930	3	3660	3	5530	3	7270	3	8940	78°	11060
4	587	4	1945	4	3680	4	5550	4	7290	4	8950	79°	11110
5	599	5	1960	5	3700	5	5570	5	7310	5	8970	80°	11160
6	610	6	1975	6	3720	6	5590	6	7320	6	8980	81°	11220
7	621	7	1990	7	3740	7	5600	7	7340	7	8990	82°	11260
8	633	8	2005	8	3760	8	5620	8	7350	8	9010	83°	11310
9	643	9	2020	9	3775	9	5640	9	7370	9	9020	84°	11350
7°	653	17°	2045	27°	3790	37°	5660	47°	7390	57°	9040	85°	11380
1	664	1	2060	1	3810	1	5680	1	7410	1	9060	86°	11420
2	676	2	2075	2	3830	2	5700	2	7420	2	9070	87°	11450
3	687	3	2090	3	3850	3	5710	3	7440	3	9090	88°	11470
4	698	4	2105	4	3870	4	5730	4	7460	4	9100	89°	11490
5	710	5	2130	5	3890	5	5750	5	7480	5	9120	90°	11500
6	720	6	2145	6	3910	6	5770	6	7490	6	9130		
7	732	7	2160	7	3930	7	5790	7	7510	7	9140		
8	743	8	2180	8	3950	8	5810	8	7530	8	9160		
9	754	9	2195	9	3965	9	5820	9	7540	9	9170		
8°	765	18°	2210	28°	3980	38°	5840	48°	7560	58°	9180		
1	776	1	2225	1	4000	1	5860	1	7580	1	9200		
2	788	2	2245	2	4020	2	5880	2	7590	2	9210		
3	800	3	2260	3	4040	3	5890	3	7610	3	9230		
4	811	4	2275	4	4060	4	5910	4	7630	4	9240		
5	823	5	2290	5	4080	5	5930	5	7640	5	9250		
6	835	6	2310	6	4100	6	5950	6	7660	6	9270		
7	846	7	2330	7	4120	7	5970	7	7680	7	9280		
8	859	8	2345	8	4140	8	5980	8	7690	8	9300		
9	871	9	2360	9	4160	9	6000	9	7710	9	9310		
9°	882	19°	2375	29°	4180	39°	6020	49°	7730	59°	9320		
1	895	1	2390	1	4200	1	6040	1	7750	1	9340		
2	907	2	2405	2	4220	2	6060	2	7760	2	9350		
3	921	3	2425	3	4240	3	6080	3	7780	3	9360		
4	935	4	2440	4	4260	4	6090	4	7800	4	9370		
5	949	5	2455	5	4280	5	6110	5	7820	5	9390		
6	962	6	2470	6	4300	6	6130	6	7830	6	9400		
7	975	7	2485	7	4320	7	6150	7	7850	7	9410		
8	989	8	2505	8	4340	8	6160	8	7870	8	9430		
9	1000	9	2520	9	4350	9	6180	9	7880	9	9440		

TABLE I

DECLINATION

The position of the earth in its orbit around the sun, and the resulting position of the earth's axis with relation to the sun, control declination, which is measured as the number of degrees the earth's axis departs from a plane that is normal to the sun's direct rays. As shown in figure 4, on 21 March and 23 September the earth's axis is in a plane normal to the sun's rays. On these two dates the declination is, therefore, zero. As the earth swings along its orbit after each of these dates, the axis declines progressively, so that on 21 June and 21 December maximum declinations of 23.45° are reached.

When the North Pole inclines toward the sun, the declination is north and is indicated as **S** (for **SAME**) on figure 3 and on the charts. When the South Pole inclines toward the sun, the declination is south and is indicated as **C** (for **CONTRARY**). When the declination is the **SAME** as the latitude in one hemisphere, it is **CONTRARY** in the other. Summer occurs when the declination and latitude are the **SAME**; winter occurs when the declination is **CONTRARY** to the latitude.

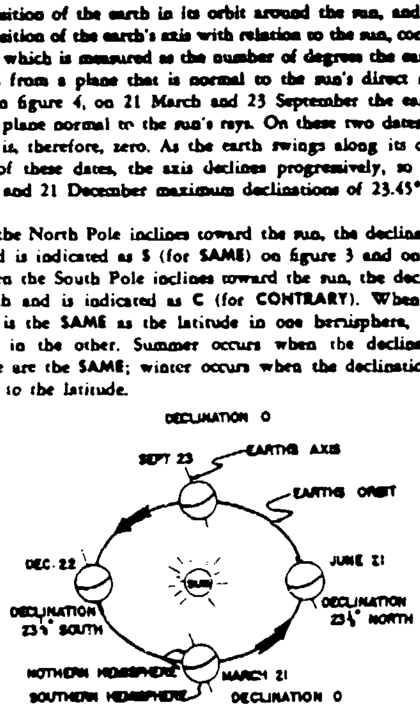


Figure 4. Earth's orbit around sun, showing positions of maximum and minimum declination.

DEFINITIONS

MERIDIAN: The meridian of a place is the upper branch of a great circle of the earth, namely the semi-circle which joins the poles and passes through the place. In simplest terms, it is merely the north-south line that passes through any place on the earth's surface.

PRIME MERIDIAN: The north-south line passing through the Royal Observatory at Greenwich, England. It is used as the 0° meridian of longitude and as the basic meridian for reckoning international zone time.

INTERNATIONAL TIME ZONE MERIDIANS: The 24 meridians from 0° to 180° longitude, both east and west inclusive, in even multiples of 15°.

STANDARD TIME ZONE MERIDIANS: The selected meridian of an area, generally a land area or the area closely surrounding a group of islands, which meridian establishes the standard time (clock time) for that area.

INTERNATIONAL ZONE TIME: Time reckoned from the international zone meridian for that zone; or time reckoned from the prime meridian and the zone hour difference. International zone time and standard zone time are the same when both are applied to one of the 24 regular international time zones (see previous discussion and table 2).

STANDARD TIME: Time reckoned from any selected meridian; it is generally the legal time to which all clocks throughout an area conform. Standard time is the same as international zone time when the selected standard zone meridian is one of the international time zone meridians and the standard zone boundaries are the same as the international time zone boundaries of the particular zone.

TRUE SUN TIME: True sun time and apparent sun time are the same thing — the time indicated by the motion of the sun each day. The sun time at a given place is called local apparent time, which is the time measured by a simple sun dial.

LOCAL APPARENT NOON: The instant the sun crosses the meridian of a place. At that instant the sun reaches its highest point in the sky on any given day.

MEAN SOLAR TIME: The average or mean time of the true sun; in other words, true sun time minus the equation of time.

EQUATION OF TIME: The number of minutes of difference between the true sun schedule and the average sun schedule which, when added algebraically to mean solar time, will give true sun time. The curve of the equation of time (fig. 3) was derived from a table compiled by the U.S. Naval Observatory.

DAYLIGHT SAVING TIME: Zone time plus 1 hour.

HOURS: Hours in this book are counted in one series from 0 to 24, beginning with midnight, instead of being counted in two 12-hour series, one each for a. m. and p. m. Hence, 11:24 a. m. is written 1124, or 1124 hours; 1:36 p. m is written 1336, or 1336 hours.

LONGITUDE: The longitude of a place is its angular distance east or west of the prime meridian, i. e., east or west of longitude 0°

LATITUDE: The latitude of a place is its angular distance north or south of the equator. The equator is 0° latitude.

DECLINATION: The number of degrees the earth's polar axis departs from a plane that is at right angles to the rays of the sun.

DIURNAL: The apparent daily circular path of the sun as seen from any given place on earth.

INTERNATIONAL CANDLE, formerly called the British Standard Candle, the flame of which, burning under certain conditions, consumes 120 grains of spermaceti per hour. This candle is a common unit of light-giving power.* An ordinary tallow candle produces

* "The new candle or candela (adopted in Great Britain and in the U.S. on 1 January 1948) is defined as one-sixtieth of the luminous intensity of one square centimeter of the surface of a black body [light radiator] at a temperature of freezing platinum, and is less than two percent lower than the international candle."[3]

[3] W. E. K. Middleton *Vision Through the Atmosphere* University of Toronto Press, 1952.

luminous energy per unit of time very similar to that from an International Candle. The light-giving value of an ordinary incandescent lamp (electric light bulb) is generally specified by its candle power.

ILLUMINATION is the effect produced when the luminous energy we call light falls upon a receiving surface.

ONE FOOT CANDLE (fc) is the luminous energy received on any part of a surface per unit of time, when the surface is normal to and one foot distant from a light power source of one international candle. In this book the foot candle units given on the plates refer to the illuminating effect of natural illumination received on a fully exposed *horizontal surface* (fig. 5).

CIVIL TWILIGHT: Illumination, independent of the moon, which ranges on average clear nights from 42 fc to 3.16×10^{-1} fc, when the center of the sun's disc ranges from $-0.8°$ to $-6°$.

NAUTICAL TWILIGHT: Illumination, independent of the moon, which ranges on average clear nights between 42 fc and 7.7×10^{-4} fc when the center of the sun's disc is between $-0.8°$ and $-12°$.

ASTRONOMICAL TWILIGHT: Illumination, independent of the moon, which ranges on average clear nights between 42 fc and 6.05×10^{-5} fc, when the center of the sun's disc is between $-0.8°$ and $-18°$.

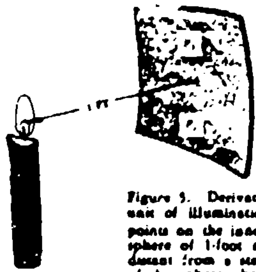


Figure 5. Derivation of the footcandle as a unit of illumination. If P_1 and P_2 are two points on the inner surface of a section of a sphere of 1-foot radius and are each 1 foot distant from a standard candle at the center of the sphere, the luminous energy per unit time and per unit area received at each point is 1 footcandle.

ILLUMINATION LEVELS

Natural illumination on the earth's surface for clear days and nights extends roughly from 11,500 fc to 3×10^{-5} fc.**

Daylight properly extends from the time of sunrise to sunset, each of which gives us 42 fc, through the zenith sun, which averages roughly 11,500 fc.

Sunrise and *Sunset* are, by definition, the instant when the top or "upper limb" of the sun's disc *appears* on the horizon. Since the charts are based on the true position of the center of the sun's disc, an allowance of 16 minutes of arc has been made for the angle between the upper limb and the center of the sun's disc, and an allowance of 34 minutes of arc has been made to compensate for refraction, which causes the upper limb to *appear* above its true position. Thus, a total of -50 minutes of arc, or $-0.8°$ solar altitude, marks the true position of the center of the sun's disc at the instant of sunrise or sunset. From table 1 or figure 6, the illumination corresponding to $-0.8°$ is found to be 42 fc.

Twilight levels have been defined in this book as those light intensities accompanying the ranges in the sun's depression which define the three twilight zones. The upper limit of all three zones is sunrise or sunset, for which the solar depression of the sun (the center of the sun's disc) is 0.8°. The low limit of solar depression for civil twilight is 6° ($-6°$ altitude). The low limit of solar depression for nautical twilight is 12° ($-12°$ altitude). The low limit of depression for astronomical twilight is 18° ($-18°$ altitude).

Moonlight may arbitrarily be considered from the condition when the quarter moon is approximately 72° above the horizon to the condition when the full moon is at the zenith. This gives us a range between 1×10^{-3} and 3.4×10^{-2} fc.

Starlight is, properly speaking, the range in light levels between 3×10^{-5} and about 1×10^{-3} fc, although some stars or planets can frequently be seen right up to the point of sunrise.

Table 3 is a rough summary for reference.

TABLE 3.
Summary of illumination levels. See also figure 6.

Condition	Limits	Sun's Altitude (degrees)	Illumination (fc)
Daylight	upper	+90.0	11,500.0
	lower	−0.8	42.0
Twilight			
Civil	upper	−0.8	42.0
	lower	−6.0	0.316
Nautical	upper	−0.8	42.0
	lower	−12.0	0.00077
Astronomical	upper	−0.8	42.0
	lower	−18.0	0.00006
Moonlight	upper	90 (full moon)	0.0345
	lower	72 (quarter moon)	0.001
Starlight	upper	−11.6	0.001
	lower	−90.0	0.000028

Supplementary Illumination Curves for Cloud and Moonlight Conditions

The basic curve of illumination as a function of solar altitude (fig. 1) gives values for clear weather, independent of moonlight. In figure 6 the basic curve is repeated, labeled "unobscured sun," and two auxiliary illumination curves for average and extreme cloud conditions are given for purposes of comparison.

Figure 6 also shows the illumination for various phases and altitudes of the moon, independent of other natural light sources. The scales and units are the same as those given for the sun.

Low Levels of Illumination

Low levels of illumination are very difficult to visualize. Take, for example, the low limit of nautical twilight. By definition, this

** The values for illumination presuppose clear weather.

occurs when the sun is 12° below the horizon. According to table 1 and figure 6, the corresponding illumination is approximately 8×10^{-4}. Since it is somewhat easier to visualize low levels of light in terms of moonlight, let us make a comparison.

Starlight of 8×10^{-4} fc is equivalent to the illumination from a full moon which is approximately 3 degrees above the horizon. The intensities of moonlight may be calculated from the relation that the light from the full moon, at a given altitude, bears to the light from the sun at the same altitude. This ratio is roughly 3 to 1,000,000.

In order, then, to calculate the altitude of the full moon for a given value of illumination, the procedure is as follows: multiply the given value of illumination from the moon by 1,000,000 divided by 3 to obtain the light which would come from the sun of the same altitude. Then, in table 1, look up the altitude for the sun which gives that illumination. This same altitude applies to full moon which will shed the given value of light. For example:

Given: an illumination value of 0.0008 fc. Then

$1{,}000{,}000 \div 3 \times 0.0008 = 267$ fc. From table 1, we find that solar altitude corresponding to 267 fc equals 3°. Hence, the full moon at altitude 3° will shed 0.0008 fc.

After the above calculating procedure was established, curves giving the illumination as a function of lunar altitudes were constructed and are shown on figure 6. In constructing these rough curves, the ratio of 3 to 1,000,000 was used, together with the graph given by Russell.[3]

To give another idea of what 0.0008 fc is like, we can say that this light obtains on the ground around us when a moon whose phase angle is 32° (and which appears to be almost full, 92.4 per cent) is 6° above the horizon and the sun well below, roughly 44°. This can be calculated in a manner similar to the above and by reference to Russell's curve, which shows that a moon of phase angle 38° sheds just half as much light as a full moon.

Although average starlight is generally regarded as slightly less than 0.001 fc, the quantity of 0.0008 fc is not easily perceptible as more than average starlight. It is, however, very much less than we generally think of as average moonlight. In the low levels of illumination, even the dark-adapted eye cannot distinguish between 3×10^{-4} and 8×10^{-4}, but it can perceive the difference in one full log cycle, say between 3×10^{-2} and 3×10^{-4}. Hence, one may be able to perceive the difference between low starlight at 3×10^{-4} and 8×10^{-3}.

On moonless nights the sky and stars contribute most of the illumination incident on a fully exposed horizontal surface when the sun is between −90° and about −18.3°. These values, however, are so low that even a young moon of phase angle 120° gives 10 times as much light when it reaches an altitude of 22° as stars and sky do without it. The maximum illumination from this young moon is about 1.24×10^{-3} fc.

The moon that looks half full — that is, the moon that appears as half a disc — is called the first or third quarter. Such a moon is also described as having a phase angle of 90°. This moon brings the night light into the astronomical twilight zone before it reaches 10° above the horizon. At 65° it gives us about 3.5×10^{-3} ...; its maximum is about 4×10^{-3} fc.

The moon of phase angle 60° (and appearing about three-quarters full) gives us 8.5×10^{-3} fc at 65° altitude. Full moon, phase angle 0°, gives us about 3×10^{-2} fc at 65° altitude. The maximum illumination from a full moon at the zenith is approximately 3.45×10^{-2} fc. It should be noted that when the moon is full (phase angle zero) and only a few degrees above the horizon, the sun is approximately the same few degrees below the horizon. Twilight, because of small depression angles of the sun, must be taken into account when one considers the light from any low altitude of moon whose phase angle is small. The illumination indicated on the moonlight curves of figure 6 is independent of the sun's influence and should therefore be added to it when moonlight and twilight occur at the same time.

It should be kept in mind that when we speak of illumination falling on a fully exposed horizontal surface at a given place as the level of illumination, or as the light condition, we are not referring to the brightness of the sky. Actually, when the illumination is 0.0008 fc by virtue of the time and place as we have been discussing and, therefore, the sun is 12° below the horizon, the greatest perceptible difference we detect is not in the increased amount of light on the ground or sea around us, but in the visibly brighter eastern sky. In the "dead of night" the starlit sky near the horizon is roughly 5×10^{-6} foot-lambert. By the time the sun gets to 12° below, the eastern sky may be 5×10^{-3} foot-lambert or more. The brightening of the eastern sky can be perceived long before 5×10^{-1} foot-lambert is reached and, therefore, before the sun gets to −12°. For example, when there is a surface haze at sea or even a fair amount of moisture in the air, a lookout whose eyes are well adapted to the "dark of night" can distinguish a clearly perceptible brightening to the eastward, near the horizon, when the sun is 18° to 22° below the horizon. At such times the illumination is only 6×10^{-4} to 4×10^{-3} fc respectively, which values are imperceptible from 3×10^{-3} fc, but the eastern sky brightness has increased quite perceptibly.

Sunlight and Skylight

On an average clear day when the total illumination is, say, in the neighborhood of 7000 fc, roughly 1000 fc is received diffusely from the sky and 6000 fc directly from the sun. However, as the sky becomes completely overcast, with the illumination level dropping, say, to 4000 fc, this light may be considered sunlight entirely. On the other hand, on extremely clear, dry days the ratios of sunlight to skylight of 10 to 1 or of 12 to 1 are not uncommon. Likewise, as one ascends from sea level (the place for which the figures in this book apply) to higher and higher altitudes the ratio of sunlight to skylight increases markedly. Complete figures are not yet available, but one measurement made at 25,000 feet on a clear day showed the ratio of the sunlight to the skylight falling on a horizontal plane to be approximately 25 to 1.

[3] H. N. Russell "Stellar Magnitudes of Sun, Moon, and Planets" *Astrophysical Journal* vol. 43, March 1916, p. 117.

SOME RULES FOR CALCULATING THE MAXIMUM AND MINIMUM ALTITUDE OF THE SUN

Outside of the tropics, the declination cannot exceed numerically the latitude. Therefore, the maximum or minimum solar altitude for any given day and given latitude of more than 23.5° can be calculated very simply as follows:

RULE 1. Maximum solar altitude equals 90° minus latitude plus declination for noon of that day.

RULE 2. Minimum solar altitude equals −90° plus latitude plus declination for midnight of that day.

Example 1. Given: 32° N latitude; 21 May; declination 20° S. Maximum solar altitude = 90 − 32 + 20 = 78°

Example 2. Given: 32° N latitude; 21 May; declination 20° S. Minimum solar altitude = −90 + 32 + 20 = −38°

Inside the tropics the declination may exceed the latitude and have the same sign S or contrary sign C.

RULE 3. When declination S exceeds the latitude, maximum altitude equals 90° plus latitude minus declination S.

RULE 4. When both declination and latitude are the same, whether the declination exceeds latitude or not, minimum altitude equals −90° plus latitude plus declination.

RULE 5. When the declination is contrary to the latitude, whether it exceeds the latitude or not, maximum altitude equals 90° minus the latitude minus the declination.

RULE 6. When the declination exceeds the latitude, with declination C, the minimum altitude equals −90° minus the latitude plus the declination.

Example 3. Declination same, exceeding the latitude.
Given: 15° N latitude; declination 20° S.
Maximum solar altitude = 90 + 15 − 20 = 85°

Example 4. Declination same.
Given: 15° N latitude; declination 20° S
Minimum solar altitude = −90 + 15 + 20 = −55°

Example 5. Declination contrary to latitude.
Given: 15° N latitude; declination 20° C
Maximum solar altitude = 90 − 15 − 20 = 55°

Example 6. Declination contrary to and exceeding the latitude.
Given: 15° N latitude; declination 20° C
Minimum solar altitude = −90 − 15 + 20 = −85°

Illumination values corresponding to maximum and minimum solar altitudes can be found in table 1, thus giving the extreme light range for any day at any place quite easily. For example, let us take the midsummer day with declination 23.5° S for four places. (See table 4 below.)

TABLE 4. Maximum and minimum solar altitudes and illumination levels in midsummer.

Place	Solar Altitude (degrees)	Illumination (fc)
North Pole (90°N)	Max = 90 − 90 + 23.5° = 23.5°	3145
	Min = −90 + 90 + 23.5° = 23.5°	3145
Latitude 75°N	Max = 90 − 75 + 23.5 = 38.5°	5930
	Min = −90 + 75 + 23.5 = 8.5°	823
Latitude 40°N	Max = 90 − 40 + 23.5 = 73.5°	10,760
	Min = −90 + 40 + 23.5 = −26.5°	3.5×10^{-3}
Equator (0°N)	Max = 90 + 0 − 23.5 = 66.5°	10,150
	Min = −90 + 0 + 23.5 = −66.5°	2.8×10^{-3}

GENERAL PROCEDURE FOR USE OF THE CHARTS

To find the light value for any given time and place:

1. Look up the latitude and longitude of the place from a map or chart.
2. Look up declination and the equation of time for the date in question (from fig. 3).
3. Convert standard time (also called clock time) to local apparent time (also called true sun time), making correction for both longitude and equation of time as explained above.
4. Select the plate for the latitude in question and, using the appropriate declination curve, read the illumination corresponding to the local apparent time; or, select the plate for the appropriate declination and, on the hour curve for the local apparent time, read the illumination value corresponding to the given latitude.

The charts are constructed to show the illumination corresponding to the altitude of the true sun at a given locality. In place of a solar altitude scale, however, we have provided an hour scale and called it local apparent time. Since only sun dials measure local apparent time, it becomes necessary to convert clock time to local apparent time before entering the charts to find the illumination.

The Latitude Series of plates (1 through 17) presents mean illumination values throughout the year at individual latitudes. Each plate in this series applies to a given latitude as shown in the large numeral at the upper right corner of the plate. Each plate contains a family of curves, each curve representing a given day of any year when the declination of the sun is as indicated on the curve. Curves are marked with 12° C, 6° S, 0°, 6° C, 12° C, etc., to indicate declination SAME or declination CONTRARY. In this Latitude Series the illumination is plotted continuously as a function of time from midnight to noon and applies conversely from noon to midnight as indicated on the time scale.

The Declination Series (plates 18 through 43) presents mean values of illumination throughout the world on individual days. Each pair of these charts applies to those days of the year when the declination is as indicated by the large numeral at the top outside corner of each plate. Each plate contains a family of curves, each curve representing a given hour of the day. The illumination is plotted continuously as a function of latitude from pole to pole. The left hand sheets, marked CONTRARY, represent the southern hemisphere when the declination is north and represent the northern hemisphere when the declination is south. The right hand sheets, marked SAME, represent the northern hemisphere when the declination is north and represent the southern hemisphere when the declination is south.

Example 1

The simplest example for finding the illumination is one which needs no time correction or interpolation.

PROBLEM: *Find the average illumination from sun and sky incident on a fully exposed, upturned plane surface at a given place and time.*

Given: Place, 75° west longitude
40° north latitude
Time, 0900, 15 April

1. Look up declination (fig. 3): Approximately 10° north.
2. Look up equation of time (fig. 3): 0.
3. Since the longitude of this place is in the center of the time zone, (on the zone meridian) there is no need to correct from zone (clock) time to mean sun time — in this case they are the same.
4. Since for the given date the equation of time is zero, there is no need to correct for irregularity in the sun's schedule.
5. It is necessary, therefore, only to refer to the curve for 10° declination, latitude SAME (plate 29), and note where the 0900-hour curve crosses the 40° latitude line. The value of illumination, as given in the vertical scale at the side of the chart, is 6.1×10^3 or 6100 fc. Or, we could find the same thing on the chart for latitude 40° (plate 7) by using the 10° S declination curve extended (or by interpolating between the 6° and 12° declination curves) where it crosses the 0900-hour line. In either case the illumination may be read as approximately 6100 fc.

Example 2

Frequently it is desirable to get only a rough answer to a question.

PROBLEM: *What is the illumination at Washington, D.C. at 1000 hours EST on 11 August.*

1. From a map Washington's latitude is seen to be roughly 40° north.
2. From figure 3, the declination for 11 August is seen to be roughly 15° north (that is, 15° SAME as latitude).
3. Refer to plate 7 (latitude 40°). The two nearest appropriate declination curves that cross the 10 o'clock line are 12° S and 23.5 S. By inspection, the illumination is seen to be rougbly between 8000 and 9000 fc.
4. A second simple approach is possible. Look up the chart for 14° declination, latitude SAME (plate 33). The 1000-hour curve crosses the 40° latitude line at roughly 8500 fc. Plate 35 (declination 16° latitude SAME) shows roughly 8700 fc. Illumination for 15° would then be roughly 8600 fc.

In the foregoing solutions to example 2, Eastern Standard Time only was used. This procedure is not very accurate since the EST zone covers too broad an area to be in keeping with the average movement of the sun relative to the horizon. It is better to correct Eastern Standard Time for longitude at the given place and for the irregularities in the sun's average schedule and find a more accurate solution, as follows.

1. Look up latitude and longitude to the nearest degree for Washington, D.C.: 39°N, 77°W.
2. Determine declination to the nearest tenth of a degree (fig. 3): 15.3° north.
3. Look up equation of time for 11 August to the nearest minute (fig. 3): −5 minutes.
4. Compute longitude correction for time difference to convert EST to mean solar time at Washington, D.C.

77° W = (longitude of Washington, D.C.)
75° W = (longitude of EST zone meridian)
2°
4 minutes per degree
8 minutes of time
1000 hours EST
−8 minutes (subtract because Washington is west of zone meridian)
0952 hours mean solar time at Washington, D.C.

5. Correct for irregular sun schedule by converting mean solar time to true sun time for the day in question, 11 August.

0952 hours mean solar time
−5 minutes equation of time for 11 August
0947 hours true sun time

6. The chart for 14° declination, latitude SAME (plate 33), shows illumination values as follows:

8400 fc at 1000 hours
6700 fc at 0900 hours
1700 fc difference. By interpolation $(47/60 \times 1700) + 6700$, we arrive at 8030 fc for 0947 hours, declination 14°.

7. Plate 35, the chart for 16° declination, latitude SAME, gives illumination values as follows:

8700 fc at 1000 hours
7000 fc at 0900 hours
1700 fc difference

Again by interpolation we calculate 8330 fc for 0947 hours, declination 16° latitude SAME.

8. However, 15.3° is the accurate average declination for 11 August; therefore

$$\left[\left(\frac{15.3-14}{16-14}\right)\times(8330-8030)\right]+8030=8225\text{ fc}$$

The difference between 8600 fc, obtained by the first rough estimate, and the 8225 fc obtained by the more accurate procedure is not significant — 4 per cent in this case. However, in many other cases the difference of 13 minutes of time will make a big difference in illumination. At this same latitude and declination at an earlier hour, say around 0600 hours, 13 minutes would make the significant difference between 700 fc and 1600 fc. Just before 0500 hours there would be an even more noticeable difference of between 4 fc and 35 fc.

It is just as well, therefore, to inspect the curves before accepting a rough estimate which may be off by a factor of 10 or more. On the other hand, inspection of either one of the plates, 33 or 35, will show that there is a very little difference between the illumination for 40° latitude and that for 39° latitude around 10 o'clock. Plate 7 shows an even slighter increase in illumination between 15° and 15.3° declination. Hence, the refinement is really a waste of time in this case.

Example 3

PROBLEM: *Find the light value at 0340 hours Pacific Standard Time, on 16 June at San Diego, California.*

1. San Diego: Latitude 32.7° N; Longitude 117.3° W.
2. Declination on 16 June: 23° north.
3. Equation of time on 16 June: −1 minute.
4. Convert standard time to local apparent time.

0340 hours PST
−1 minute (equation of time)
0339 hours

120° zone meridian
117.3° San Diego longitude
2.7°

$2.7° \times 4$ minutes per degree $= 11$ minutes.

Since San Diego is east of the zone meridian, the time will be later, according to the sun, at San Diego, than at the zone meridian. Therefore, the 11 minutes will be added, and local apparent time will be

$$0339 + 11 = 0350 \text{ hours.}$$

5. Using the 30° latitude chart (plate 5) select the declination curve for 23.5° S, which gives, for 0350, illumination of 3.7×10^{-4} fc.

6. Using the 35° latitude chart (plate 6), read from the 23.5° S curve the illumination value for 0350, which is 3.8×10^{-4} fc.

7. By graphic interpolation, calculate the illumination for latitude 32° and time 0350, as 8×10^{-4} fc, or 0.0008 fc.

8. As a check, use the 23.5° declination chart, latitude SAME (plate 43). The 0300 curve at 32.7° latitude gives 5×10^{-5} fc. The 0400 curve gives 4×10^{-4}. By interpolation, we calculate the illumination for 0350 at 32.7° to be 8×10^{-4} or 0.0008 fc.

By reference to table 1, we find the solar altitude for 8×10^{-4} fc is approximately −12°, that is, about 12° below the horizon. This, by definition, is the beginning of nautical twilight. For more extensive discussion of low levels of illumination, see page 5.

Example 4

PROBLEM: *Find the average value of the natural illumination that obtains at 0600 hours in Foochow, China, on 25 December.*

1. Look up the approximate latitude and longitude of Foochow (Foochow is now also called Minhow). Latitude, 26° N. Longitude, 119.25° E.

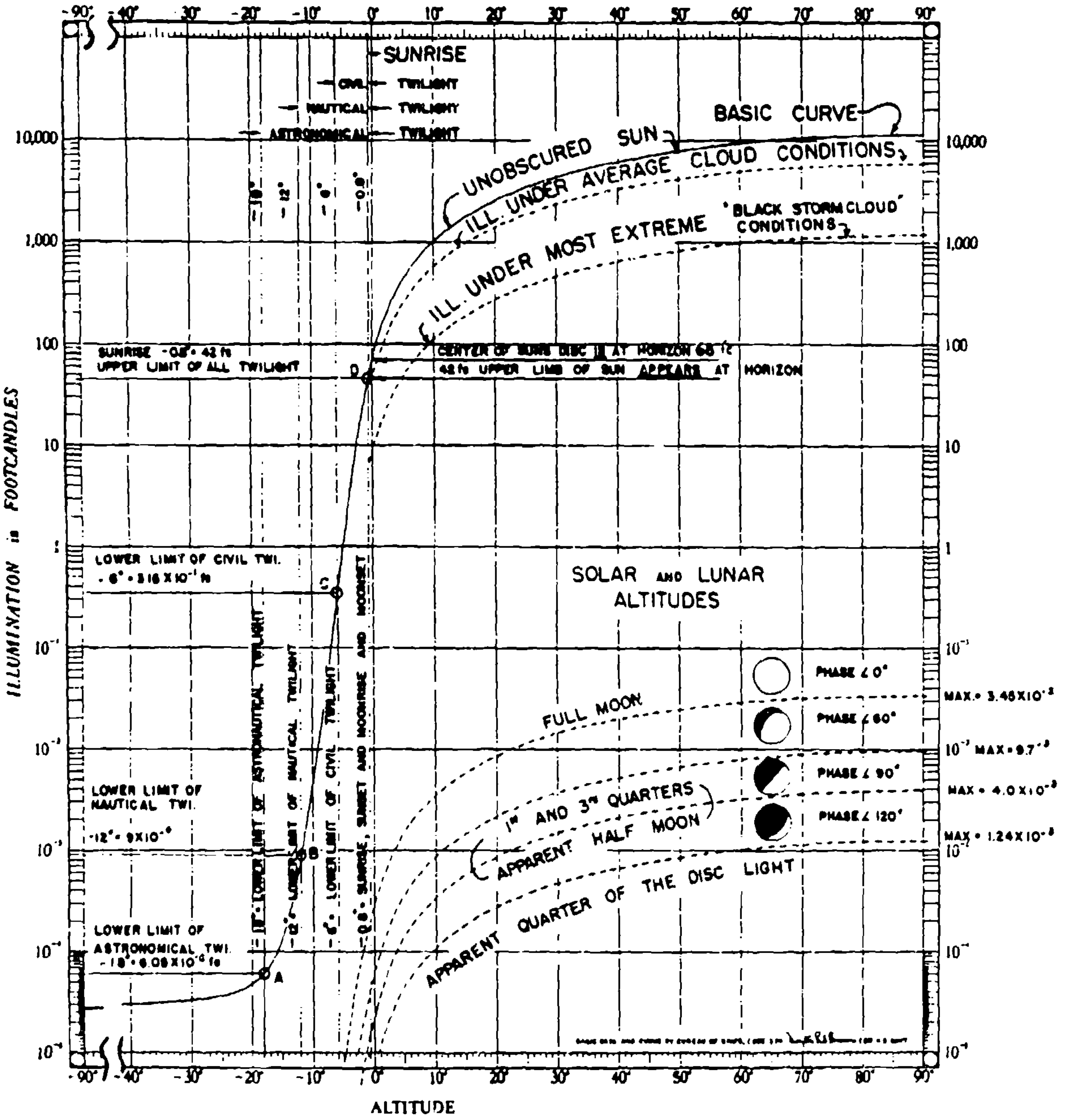
2. From figure 3 the equation of time for 25 December is found to be negligible, and declination for 25 December is 23.5° south.

3. Correct the clock time used in Foochow to the local apparent time. Inasmuch as the equation of time is negligible for 25 December, no correction is made for it. To correct for longitude (4 minutes of time per degree away from the time zone meridian), $(120° - 119.25°) \times (4) = 3$ minutes. Since Foochow is west of the time zone meridian, the sun will not reach Foochow as soon as it does the place for which the clocks are set, and consequently the 3 minutes for longitude will be subtracted from clock time: $0600 - 3 = 0557$ hours local apparent time.

4. Select the 23.5° declination chart, latitude CONTRARY (plate 42). Follow the vertical 26° latitude line up to 0557 hours (about a half inch below the 0600 hour curve) and read illumination as 2.2×10^{-3} fc or 0.0022 fc.

5. Check by looking at the 25° and 30° latitude charts (plates 4 and 5): at 0557 in latitude 25°, illumination is 3×10^{-3} fc; at 0557 in latitude 30°, illumination is 7×10^{-4} fc.

By interpolation, the illumination for 0557 in latitude 26° is 2.19×10^{-3} fc, or 0.00219 fc. Reference to table 1 shows that this light obtains when the altitude of the sun is approximately −10.80°.


SUNRISE
CIVIL TWILIGHT
NAUTICAL TWILIGHT
ASTRONOMICAL TWILIGHT
BASIC CURVE
UNOBSCURED SUN
ILL. UNDER AVERAGE CLOUD CONDITIONS
ILL. UNDER MOST EXTREME "BLACK STORM CLOUD" CONDITIONS
SUNRISE -0.8° = 42 fc UPPER LIMIT OF ALL TWILIGHT
CENTER OF SUNS DISC IS AT HORIZON 68 fc
42 fc UPPER LIMB OF SUN APPEARS AT HORIZON
LOWER LIMIT OF CIVIL TWI. -6° = 3.16 X 10^-1 fc
SOLAR AND LUNAR ALTITUDES
-18° LOWER LIMIT OF ASTRONAUTICAL TWILIGHT
-12° LOWER LIMIT OF NAUTICAL TWILIGHT
-6° LOWER LIMIT OF CIVIL TWILIGHT
-0.8° SUNRISE, SUNSET AND MOONRISE AND MOONSET
PHASE ∠ 0°
PHASE ∠ 60°
PHASE ∠ 90°
PHASE ∠ 120°
MAX = 3.45 X 10^-2
MAX = 9.7^-3
MAX = 4.0 X 10^-3
MAX = 1.24 X 10^-3
FULL MOON
1st AND 3rd QUARTERS
APPARENT HALF MOON
APPARENT QUARTER OF THE DISC LIGHT
LOWER LIMIT OF NAUTICAL TWI. -12° = 9 X 10^-4
LOWER LIMIT OF ASTRONOMICAL TWI. -18° = 6.08 X 10^-5 fc
ILLUMINATION in FOOTCANDLES
ALTITUDE
A
B
C
D

Example 5

PROBLEM: *Find the approximate time of sunrise or sunset at a given place and date.*

Given: Chicago, Illinois, 21 December.

1. The position of Chicago is 41.9°N; 87.6°W.
2. From figure 3, declination for 21 December is found to be 23.5° south, and the equation of time is 2 minutes.
3. From figure 6, the illumination at sunrise and sunset is found to be 42 fc.
4. On plate 7 (40° latitude) the 23.5° C curve reaches 42 fc at about 0720 hours.
5. On plate 8 (45° latitude) the 23.5° C curve reaches 42 fc at about 0737 hours.
6. By interpolation, we get 0723 hours for sunrise or 1637 hours for sunset.
7. Convert this local apparent time to CST. First, look up the equation of time (fig. 3): −2 minutes, and subtract it algebraically from sun time.*

0723	true sun time	1637
−2	minutes (equation of time)	−2
0721	mean sun time	1635

Then also correct for longitude.

90° CST zone meridian
87.6°
2.4° × 4 minutes per degree = 9.6 minutes
0721 − 10 = 0711 CST (or 1635 − 10 = 1625 CST).

Example 6

PROBLEM: *Find the sun's altitude at a given time and place.*

Given: New Orleans, La., at 0800 hours on 16 April.

1. New Orleans: 30°N; 90°W.
2. From figure 3, the declination of the sun of 16 April is found to be 10° north.
3. The equation of time for 16 April (fig. 3) is found to be zero and, because New Orleans is on a zone meridian, there is no correction for time necessary because of longitude either.
4. From plate 5 (30° latitude), illumination for the given time is found to be 4600 fc.
5. From plate 29 (declination 10°, latitude SAME), check the 0800 curve where it crosses the 30° latitude line; again the illumination is found to be 4600 fc.

From inspection of the basic curve (fig. 1), which gives illumination as a function of solar altitude, it can clearly be seen that the degree of precision in determining solar altitude from the illumination is dependent upon an equally precise reading of illumination. Since only the approximate illumination for a given time and place can be read from the charts, it follows that the sun's altitude can only be approximated in this manner. It may also be noted that, since the basic curve is for the average values of illumination for average clear days, one cannot, by taking a meter out of doors and making one measurement of the illumination at any one time and place, deduce that the sun will be at the corresponding altitude as given on the basic curve (fig. 1). However, since the altitudes for the sun were first accurately calculated and corresponding values of illumination assigned as the basis for the numbered plates, it is perfectly good procedure to determine the sun's altitude from the charts and table 1 for any place and true sun time.

6. Thus, having ascertained the illumination from the charts, turn to table 1 to find the solar altitude corresponding to 4600 fc; this altitude is found to be 31.2°.

Example 7

PROBLEM: *Find the sun's altitude at 1600 hours on 1 April in St. Paul, Minnesota.*

1. The position of St. Paul: 45°N; 93°W.
2. Declination for 1 April: 4° north (fig. 3).
3. Equation of time for 1 April: −4 minutes (fig. 3).
4. Correct time for longitude:

90°
−93°
−3° × 4 minutes per degree = −12 minutes

1600 hours CST
−12 minutes
1548 hours local mean time

5. Correct time for equation of time:

1548 hours local mean time
−4 minutes
1544 hours local apparent time

6. From plate 8 (latitude 45°) the illumination for 1544 hours, declination 4° S, is found to be approximately 3600 fc. From table 1, corresponding solar altitude is approximately 26°.

Example 8

PROBLEM: *Find the time each day of the year when, at a given place, the sun will be at a certain altitude (or when a certain light level will obtain at a given place).*

Given: New Orleans, La.; solar altitude 26°.

1. Position of New Orleans: 30°N; 90°W.
2. From table 1, determine the illumination at 26° altitude: 3600 fc.

* In converting from true sun time (as given on the charts) to standard time, it is necessary to reverse the process used in converting standard time to local apparent time. In this case the equation of time is therefore subtracted algebraically. The correction for a longitude east of the zone meridian is also subtracted.

3. On plate 5 (30° latitude), place a straightedge across the page at the 3600-fc level. Each curve represents a given declination which, in turn, corresponds to two days of the year (fig. 3). The points at which the straightedge crosses the declination curves will give the hours on a sufficient number of days to make a complete yearly plot.

Example 9

PROBLEM: *Compare the various levels of light that obtain at various places of different latitudes along the same meridian of longitude at any one particular instant.*

Given: 1000 hours local apparent time on 19 January.

1. The sun's declination for 19 January is approximately 23.5° south.

2. Look, then, at the two charts for the declination 23.5°; chart 42 (for latitudes CONTRARY to declination) and chart 43 (for latitudes SAME as declination). For the given date, plate 42 then represents the northern hemisphere and plate 43 the southern hemisphere. The left edge of plate 42 is the North Pole; the right edge of plate 43 is the South Pole.

3. Trace the 1000-hour curve through both charts to obtain the various levels of light occurring along the same meridian of longitude at the same time. The 1000-hour curve starts at 3.8×10^{-6} at the North Pole and rises very rapidly south of 84°N. The light at 69°N is 1 fc. At the Arctic Circle (66.54°N) the light level is 10 fc. At 52.5°N it is 100 fc and it reaches a maximum of more than 9000 fc at 25° N. Between 25° S and the South Pole it drops from 9000 fc to about 3100 fc.

Tracing the 1000-hour curve in this manner is in effect tracing the light level from the North Pole to the South Pole by going directly south on a meridian along which the local apparent time is 1000 hours.

Similar hour curves may be compared. However, it should be borne in mind that, unless one is comparing places on the same meridian, allowance must be taken for time differences.

Example 10

PROBLEM: *Compare the light at various places of different longitude along the same parallel of latitude at any given instant.*

Given: Philadelphia, Pa.; Denver, Colo.; and Reno, Nevada, at 0800 hours, EST, 21 March.

1. Positions of cities given:
   Philadelphia: 40°N; 75°W.
   Denver: 39.8°N; 105°W.
   Reno: 39.5° N; 120°W.

For the sake of this example, we can consider 39.8° and 39.5° as 40° latitude.

2. Declination for 21 March is zero (fig. 3).

3. Equation of time for 21 March is −7 minutes.

4. Convert 0800 hours EST to the local apparent time in each city.

Philadelphia:

0800 hours EST
0 correction for longitude
−7 minutes (correction for equation of time)
0753 hours local apparent time

Denver:

0800 hours EST
−2 hours (correction for longitude; 30° × −1 hour per each 15°)
0600 hours MST
−7 minutes (correction for equation of time)
0553 hours local apparent time

Reno.

0800 hours EST
−3 hours (correction for longitude)
0500 hours PST
−7 minutes (correction for equation of time)
0453 hours local apparent time

5. From plate 7, we find that:
   at Philadelphia the illumination is 2800 fc;
   at Denver the illumination is 30 fc, and
   at Reno the illumination is 0.0004 fc.

Example 11

PROBLEM: *Compare time rates at which the illumination changes in different parts of the world and/or at various days and hours.*

There are big differences in the rate of natural illumination changes. The slopes of curves denote these rates. A steep slope denotes a rapid rate of change. A flat slope a gradual change rate.

Since changes in the illumination accompany changes in the altitude of the sun, as shown in the ba[illegible] curve, it follows that where the sun ascends most rapidly, there also will the illumination increase most rapidly. Also, the converse is true.

The steepest portion of the basic curve lies between −7° and −5°, where the illumination changes precisely one order of magnitude; 0.1 fc to 1 fc, hence, by a factor of 5 per degree. This fact, coupled with the fact that the sun rises faster at the equator than at any other latitude (0.25° per minute), gives us the maximum rate of increase of illumination of one order of magnitude in 8 minutes of time: 112.5 per cent increase per minute.

The slowest rate of change occurs at the poles — at the North Pole around 22 December and at the South Pole around 21 June. Here the rate of change is 0.014 per cent increase per minute.

By comparison, the fastest rate of change is 8000 times the slowest rate.

Example 12

PROBLEM: ***Find the range of values of illumination throughout a given day at any given place.***

Given: 1 June, San Francisco, California.

1. From a crude map the latitude of San Francisco is approximately 38°N.
2. From figure 3 the declination on 1 June is found to be 22°N.
3. Since the declination and the place are both the same (both north) select the 22° S curve on the chart for 35° latitude (plate 6), and also the 22° S curve on the chart for 40° latitude (plate 7), and interpolate for 38°. Values for 35° latitude range from 3.2×10^{-5} fc at midnight to 11,000 fc at noon. Values for 40° range from 3.42×10^{-5} fc at midnight to 10,650 fc at noon. By interpolation it is found that values for 38° range from 3.3×10^{-5} at midnight to 10,800 fc at noon.

The same limiting values may be obtained without interpolation on the chart for 22° declination, latitude SAME (plate 41), but the intermediate values and the character of the rates of change throughout the day are not as clearly presented.

A curve for 38° latitude can be plotted from 15 points taken directly from plate 41, on which 11 even hour curves and four intermediate curves cross the 38° line.

In plotting the illumination throughout any day at a given place, it is helpful to incorporate the correction for longitude into the time scale. This factor is constant for the place and results merely in shifting the time scale given in the charts to right or left to compensate for four minutes of time per degree that the place is east or west of the time zone meridian.

ANNUAL ILLUMINATION

In studying the illumination throughout a year at a given place, it has been found very helpful to visualize the apparent path of the sun during a year at that place. The yearly path of the sun is divided into daily paths (diurnals) for convenience. The sun's daily path relative to the horizon follows three simple laws:

1. The plane of the diurnal makes an angle with the horizon of a place equal to the place's co-latitude (90° minus latitude).
2. At any given place the diurnal planes are parallel throughout the year.
3. As the declination progresses from 23.5° S to 23.5° N and returns, the diurnal also progresses along an axis which passes through the place and is parallel to the polar axis of the earth.

Figures 7 through 10 show the progress of the diurnal throughout the year in four different locations.

On figure 8, note that on the two dates, 21 March and 23 September, not only does the horizon divide the diurnal into equal day and night (equinox) but the diurnal cuts the horizon equally between north and south. Hence, when the declination is north, the diurnal meets the horizon to the north of the E-W line. When the declination is south, the reverse is true.

This process can be visualized in another way: Philadelphia, Pa., lies 40° north of the equator. As a consequence, the apparent path of the sun, the diurnal, makes an angle of 50° with the Philadelphia horizon. On 21 March, the sun rises approximately due east at approximately 0600 hours true sun time, reaches due south at noon, sun time, at an altitude of 50°, and sets approximately due west at 1800 hours, true sun time. By 1 May, the sun's declination is 15° north. On this day, the sun rises about 10° north of east at approximately 0504, true sun time, reaches a noon altitude of 65°, and sets around 1854 hours about 10° north of west. Note that the whole diurnal is shifted north and up, so that the noon position of the sun is higher than it was on 21 March by the amount of the north declination. The highest the sun ever gets in Philadelphia is 73.5°. This is reached on 21 June, when the declination is 23.5° north. The lowest noon position is 26.5°, when the declination is 23.5° south, on 21 or 22 December.

The yearly illumination at four selected latitudes — the equator, 40°N, 76.5°N, and the North Pole — is discussed in the next four sections.

Yearly Illumination at the Equator

At the equator (0° latitude), the illumination, like the solar altitude, has the widest range during one day of any place on earth — from 2.8×10^{-4} to 11,500 fc. This can occur twice a year, at the time of the equinoxes (declination 0°). These are the days when the sun goes from −90° at midnight to +90° at noon and back to −90° again by midnight. At the equator at the time of summer and winter solstice, the sun goes from −67.5° to +67.5° and back down to −67.5° (fig. 7).

In summer the sun always keeps to the north of the place (P). At the winter solstice (21 December, declination 23.5° S.) the sun has the same range in altitude as on 21 June but always keeps to the south of the place (P). The illumination values corresponding to −67.5° and +67.5° are 2.83×10^{-4} fc and 10,250 fc respectively.

At the equator, and there only, the sun rises within a few minutes of 0600 hours sun time and sets very close to 1800 hours sun time every day of the year.

On 21 March and 23 September the sun's altitude changes at the rate of 15° per hour, all day and all night. Between 0500 and 0700 hours the sun's altitude changes from −15° to +15° with corresponding illumination of 1.4×10^{-4} to 1725 fc. On 21 June and 21 December, between the same hours, the sun's altitude changes from −13.5° to +13.5° with corresponding illuminations of 2.9×10^{-4} to 1504 fc. The differences in illumination ranging over any given 2-hour interval prior to 0500 hours at the equator are imperceptible from one day to another. For, even though the light of 2.9×10^{-4} fc is roughly twice 1.4×10^{-4} fc, both are at a very low level, where a factor of about 10 to 1 is necessary before the difference is perceptible. Likewise, the differences from day to day for any succeeding hour are too small to be recognizable even for a six-month period. A summary is given in table 5.

TABLE 5. Illumination at the equator.

Hours	Illumination (fc)	
	21 March and 23 Sept	21 June and 21 Dec
Midnight	2.8×10^{-4}	2.83×10^{-4}
0500	1.4×10^{-4}	2.9×10^{-4}
0600	68	68
0700	1725	1504
1030	10,230	9120
Noon	11,500	10,250

Yearly Illumination at 40°N Latitude

Plate 7 shows the illumination for a series of days labeled according to their declinations. By inspection of plate 7, one sees that the curves are generally similar. They all start at about the same level at midnight and reach into the thousands of foot candles by noon of each clear day throughout the year. Thus the over-all range of illumination is very similar from one day to another. The change from 10^{-4} to 10^{3} takes about 2 hours and 49 minutes in midsummer and takes about 2 hours and 38 minutes on 21 December. Between 10^{-4} and 10^{3} the shape of one curve for one day is almost identical to the shape of the curve for every other day. And since the slopes of the curves are so similar throughout the year, it means that the rate of change from one value to the next within a given band is practically the same from day to day. However, you will note that the big change in illumination, from starlight to well into daylight, occurs at a different time of day every day from June to December. On 21 June it takes place from 0244 to 0530 hours, whereas on 21 December it takes place from 0557 to 0830 hours. It follows that the darker levels on one side of this steep slope, and the lighter levels on the other, change in duration from day to day. Hence, it follows that the nights are roughly 5½ hours long in midsummer compared to 12 hours long in midwinter.

The most noticeable difference between days throughout the year is the amount of light that obtains *at some one given hour* of different days. Although some differences occur at this latitude around the noon hours, the big differences occur within two hours (plus or minus) of sunrise or sunset. For example, take the hour 0530 (or 1830, which has the same light values). On 21 December at this latitude "when the day is clear," the light is slightly less than 5×10^{-4} fc. Whereas, on 21 June there will be 10 to 20 million times that amount of illumination at 0530 hours.

About 1 September the sun rises at 0530, giving 42 fc, whereas a month later the illumination given by starlight and the pale twilight is no more than the value of bright moonlight at that hour, 0.03 fc. Of course, a high full moon could add another 0.03 and make it 0.06 fc.

The noon illumination differs over the six-month period from about 3700 fc on 21 December to 10,700 fc on 21 June. Such a difference is not easily perceived by even an observant eye unless the change is very rapid. However, the corresponding difference in heat from the sun is quite easily felt. The altitude of midsummer noon sun at 40°N is 73.5°, whereas the midwinter noon sun is only 26.5° altitude (fig. 8).

Comparison of the morning hours on different dates at which seven selected light levels occur at 40°N latitude is given in table 6.

TABLE 6. Illumination at 40°N.

Illumination (fc)	Hours of Occurrence		
	21 June	21 March and 23 Sept	21 Dec
10^{-4}	0230	0434	0552
10^{-3}	0315	0456	0618
42 (sunrise)	0430	0557	0720
1000	0533	0657	0831
3700	0700	0820	Noon
8000	0900	Noon	—
10,760	Noon	—	—

Yearly Illumination at 76.5°N Latitude

The latitude of 76.5°N has been chosen because the northernmost large settlement on the earth, Thule, is at 76.5°N, and also because it was at Thule, in 1946, that the writer collected a large quantity of data on the illumination, without which these Natural Illumination Charts would probably never have been prepared.

The most amazing thing about the illumination at Thule, or any place else extremely far north or extremely far south, is the small change over long periods of time in midsummer and again in midwinter — the seemingly endless light in midsummer and the endless darkness in midwinter.

At such near-polar places the sun goes around the horizon in a gentle sloping plane rather than steeply up, over, and down. At Thule the plane slopes only 13.5° from the horizontal (fig. 9). When this whole plane is 10° or more above the horizon, as it is in midsummer (AB, fig. 9), the light of one day runs right into that of the next one without much appreciable change.

The sun's climb from midnight to noon seems very slow and, when noon finally comes, with the sun's rays slanting down from 37°, it is hard to realize that here is the highest sun of the year and the lightest it ever gets.

The difference between 1015 fc at midnight and 5660 fc at noon is really not very large. One thousand foot candles is about the light that exists when there is a high fog obscuring the sun's disc during the first week of September around 10 a. m. in San Diego, California; 5660 fc is the light experienced at kick-off time on a typical clear, cool football day in Chicago.

The difference between 1000 and 5600 fc accompanies a change in the sun's altitude from 10° and 37° at York, Pennsylvania, for example, between 0745 and noon of a clear day when the sun rises around 0645. A person in the United States can experience about this same change by walking across the street from the shaded side to the sunny side in the middle of the afternoon.

Since there is a great deal of fog and overcast all along the western coast of Greenland during the summer, the monotony of nearly constant light is even more pronounced, for fog and low stratus clouds have an evening effect. On the other hand, when cold fronts move through and anti-cyclonic conditions prevail, the sky clears to an intense blue overhead that is truly breathtaking and the visibility of mountains 100 miles or more distant is restricted only by the altitude of the observer. A clearing also changes the geometry of the lighting, producing sharper and more contrasty scenes, long shadows, and more, much more color. The level of light, however, doesn't change appreciably.

Between 1 November and 10 February the sun does not rise at Thule, Greenland, as shown in figure 9 (JK-LM). During six weeks of this period, between the first of December and 13th of January, when the sun stays below −8° the light is most monotonous. (Incidentally, the thermometer stays well below at this time also.) At all other times of clear weather, even in "the dark of the moon," the light at midday is at least equal to that of a high, bright, full moon.

But even this change from starlight to moonlight and back to starlight again day after day after day becomes very tiresome. Accompanying this rather slight variation in illumination is the general sameness of the surrounding scenery. Without the moon, the light that exists is so diffuse that the world is almost completely shadowless. Add to this the uniformly white blanket of snow which lies everywhere and frequently fills the air as well, and one can see how eerie the pale light of the long winter months can be.

Still there is great variety in the light at Thule, Greenland. Unlike the tropics, here there are four distinctly different types of days as far as broad light levels go:

1. Daylight only, when the sun stays continuously above the horizon. This occurs from 24 April to 19 August (fig. 9, AB-CD).
2. Sunlight and twilight only, from 20 August to 5 October, and again from 10 March to 23 April.
3. Sunlight, twilight, and night, from 6 October to 30 October, and again from 11 February to 9 March.
4. Twilight and night only, from 1 November to 10 February (fig. 9, JK-LM). Note that even in midwinter there are at least four hours of nautical twilight, weather permitting (plate 42).

On 24 April the sun rises but does not set.

On 19 August the sun does not rise, but sets.

From 20 August to 1 November, and again from 11 February to 23 April, the sun rises and sets.

Like every other place on the earth, excepting within a few degrees of the poles themselves, the sun is above the horizon and below the horizon for equal periods on the equinoxal dates: 21 March and 23 September (fig. 9, FG).

Table 7 is a summary of the range of illumination throughout the year. It does not allow for the equation of time nor the longitude time correction factor for Thule. In table 7, 11 February and 1 November are shown as examples because on 11 February the first sunrise of the year can occur and on 1 November the last. On these dates, the declination is about 14.3° south (fig. 9, JK).* The sun rises and sets very nearly due south on these dates. On the other hand, around 24 April, the sun rises almost due north and does not set. On 19 August it starts setting again, due north (fig. 9, CD).

* If this declination occurs before noon on 10 February, there will be a sunrise. If it occurs after noon on 1 November, the sun will rise that day also. If not (and there is a slight variation each year), the sun won't rise until 11 February or after 31 October.

TABLE 7. Illumination on selected days at Thule, Greenland 76.5°N.

Time (hours)	Illumination (fc)				
	21 December Midwinter Decl. 23.5°(C)	11 February and 1 November First and Last Days of Sunrise Decl. 14.3°(C)	21 March and 23 September Equinox Decl. 0°	24 April and 19 August Start and End of Continuous Sun Decl. 12.7°(S)	21 June Midsummer Decl. 23.5°(S)
Midnight	3.1×10^{-4}	3.4×10^{-5}	2.9×10^{-4}	42	1015
0200	3.1×10^{-4}	3.6×10^{-5}	1.1×10^{-3}	105	1250
0400	3.4×10^{-4}	4.5×10^{-5}	1.4×10^{-1}	512	1945
0600	3.9×10^{-4}	2.5×10^{-4}	68	1342	3015
0800	8.5×10^{-4}	6.3×10^{-2}	621	2405	4300
1000	9.7×10^{-4}	10.2	1235	3265	5300
Noon	4.3×10^{-3}	42.1	1504	3640	5660

Yearly Illumination at the North Pole

It would be misleading to say that at the North Pole every day is different during the two six-month periods between 21 December and 21 June. It is misleading also to say that there are six months of daylight and six months of night. For any given day, the light changes not at all save for the influence of the moon or the weather, or both.

At all times, the sun, when it can be seen, appears to stay at one place in the sky. When there are reference objects around on the ice the sun appears to go around the horizon (fig. 10) but never up, over, and down as we normally think of its doing. It takes nearly four days for the sun to rise or set. It stays between 23° and 23.5°, its maximum altitude, for six weeks.

Independent of the moon's influence, the type of light conditions that do occur at the North Pole are as follows:

Full night only	14 November to 29 January
Astronomical twilight	30 January to 17 February
Nautical twilight	18 February to 5 March
Civil twilight	6 March to 18 March
Sunrise	19 March to 23 March
Highest Sun (3100 fc)	10 June to 3 July
Sunset	21 September to 25 September
Civil twilight	26 September to 9 October
Nautical twilight	10 October to 25 October
Astronomical twilight	26 October to 13 November

(See also table 3).

CONCLUSION

In conclusion, I'd like to mention a few of the false impressions that many people acquired when they were children and which, unfortunately, many of us retained for too long a time.

1. It is wrong to refer to the quantity of light in broad terms of time or day only, such as 10 minutes after sunset, or 30 minutes before dawn. For at 30 minutes before dawn the light can be anything from one-tenth of a foot candle to 50 foot candles, depending on the time of year and the place you are talking about.

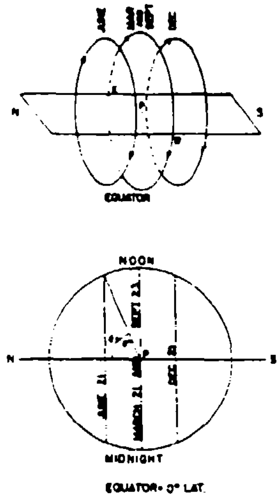
2. Days cannot just be divided between day and night. The time of year and the latitude of the place, as well as the hour of the day, effect wide variations in the altitude of the sun and hence, the light. There are a wide variety of types of days and types of nights as far as light is concerned, from the equator to the poles — some all dark, some all twilight, and so on.

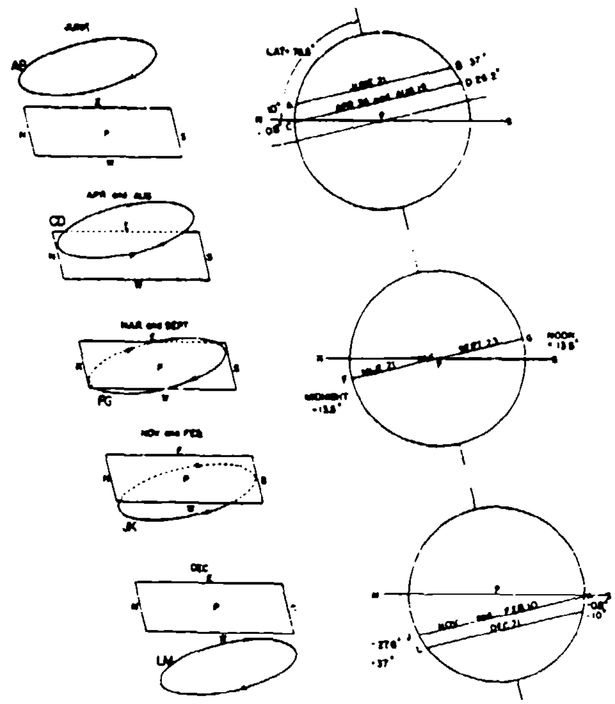
It is not always dark or twilight below the surface of the sea. The light within the sea varies greatly and depends on a number of things. The amount that enters the sea depends in large part on the amount reaching the surface from above, so that the charts contained in this book may be a guide to some degree in visualizing the light within the sea at shallow depths.

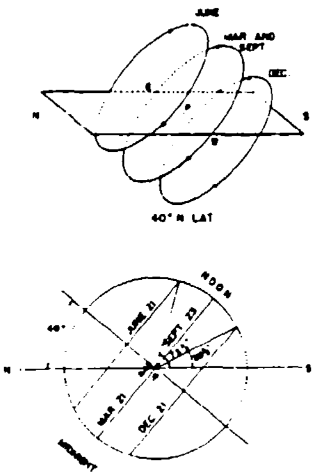
3. It is wrong to consider merely one value for starlight, one value for moonlight, one for twilight, or one for daylight, since in each case the illumination ranges over a wide scale of values. See the discussion of illumination levels (p. 5) and table 3.

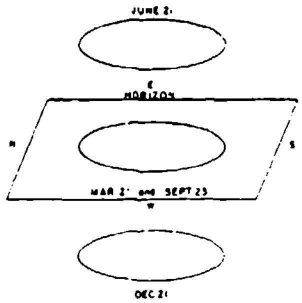
4. It is false to say that there are six months of daylight and six months of darkness at the North and So·· Poles.

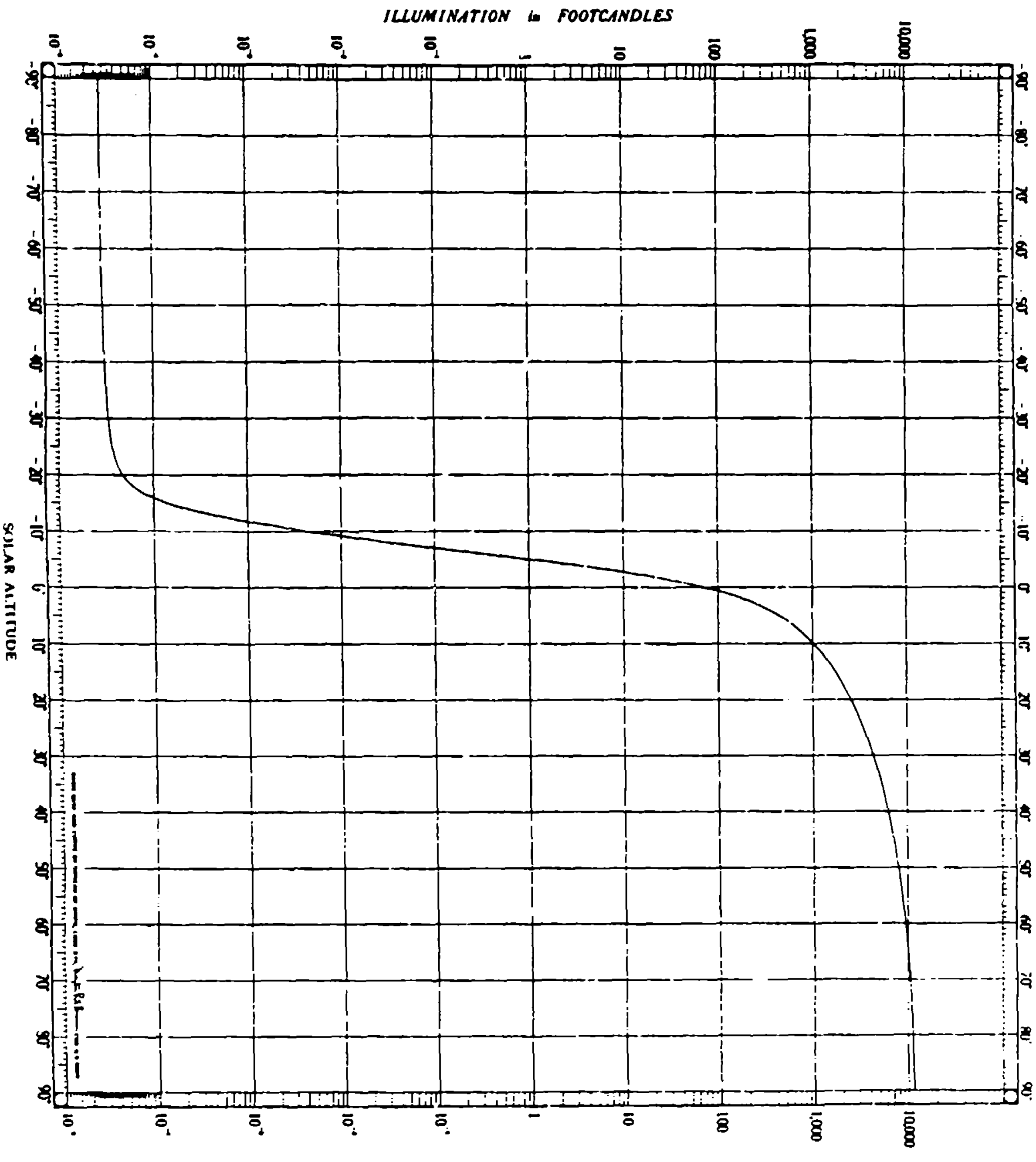
5. To the common expression, "It alw.,s seems darkest just before the dawn," should be added " . . . actually it never is, you know."


NOON
MIDNIGHT
EQUATOR
EQUATOR- 0° LAT.


APR and AUG
MAR and SEPT
NOV and FEB
DEC
SEPT 23
MIDNIGHT

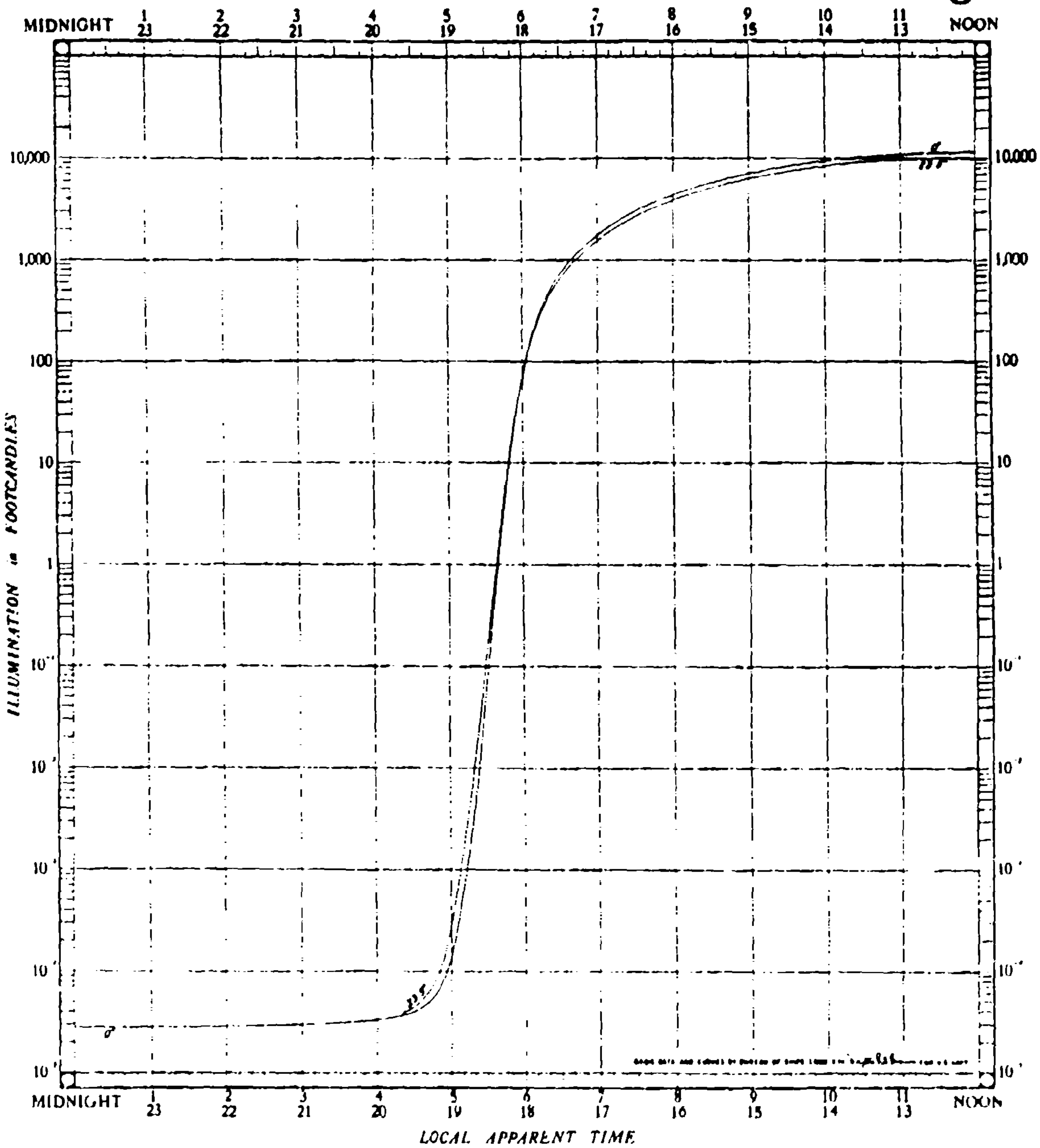

JUNE
MAR AND SEPT
DEC.
40° N LAT
NOON
MIDNIGHT

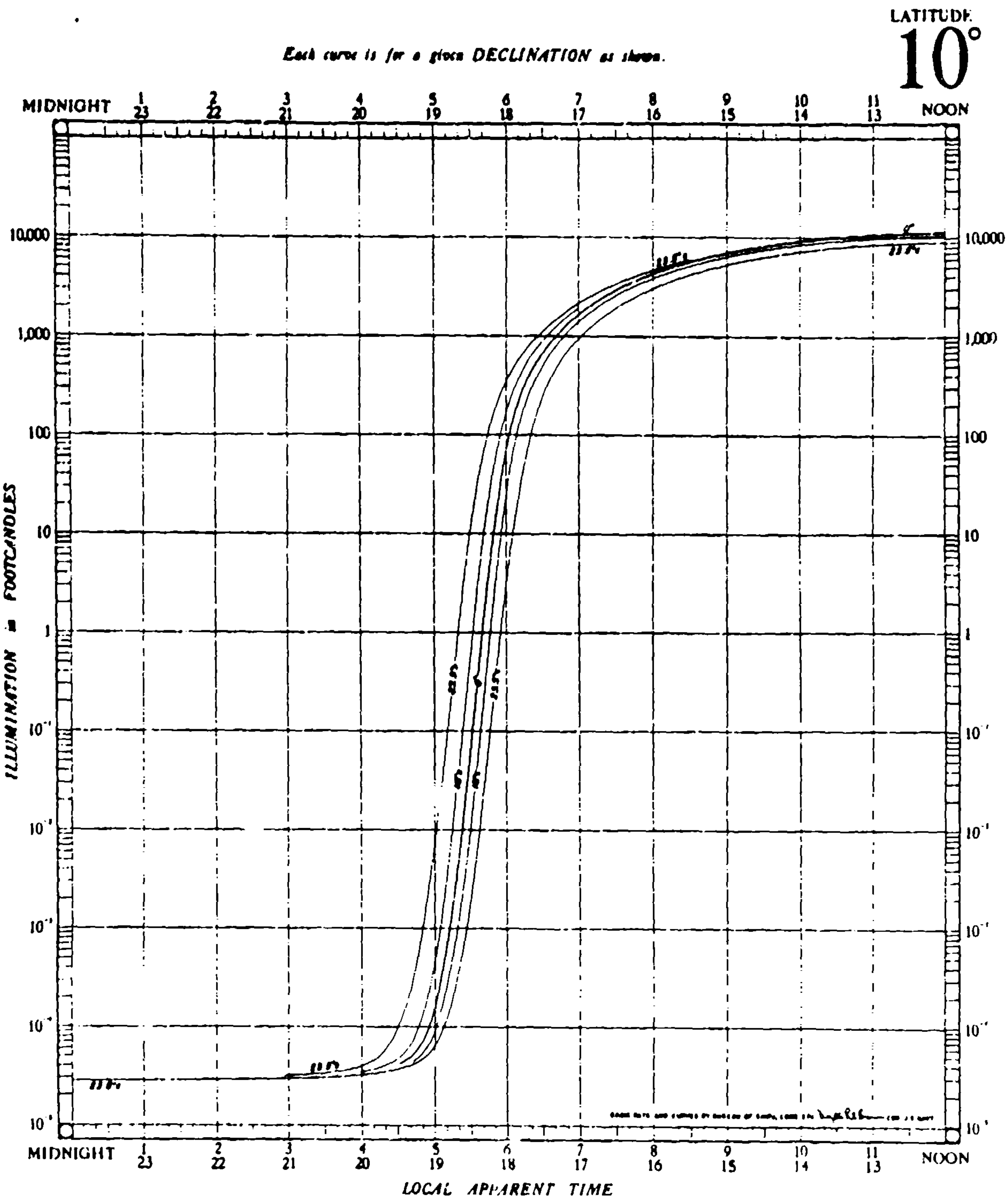

JUNE 21
HORIZON
MAR 21 and SEPT 23
DEC 21

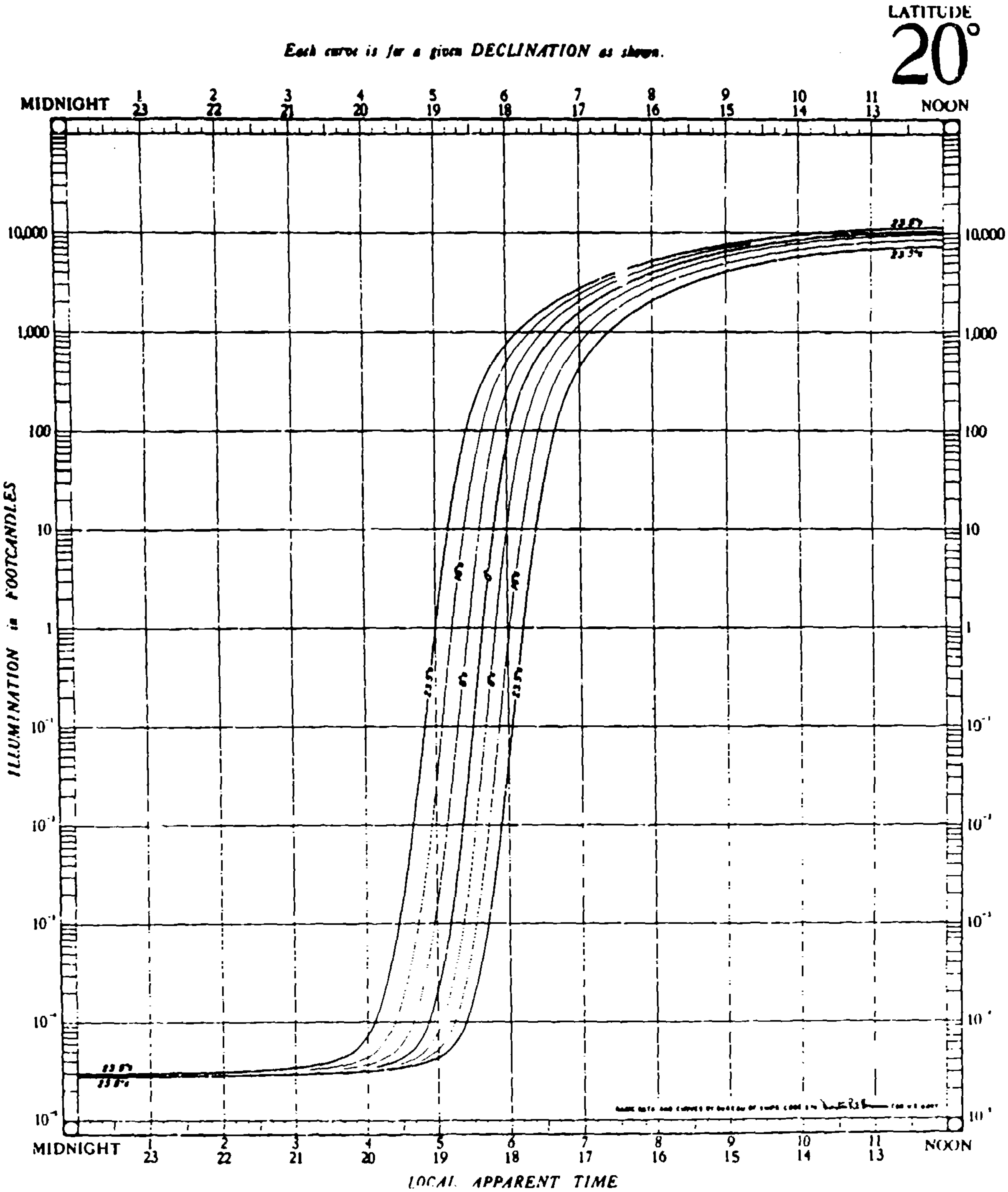

ILLUMINATION in FOOTCANDLES
SOLAR ALTITUDE
1
10
100
1,000
10,000

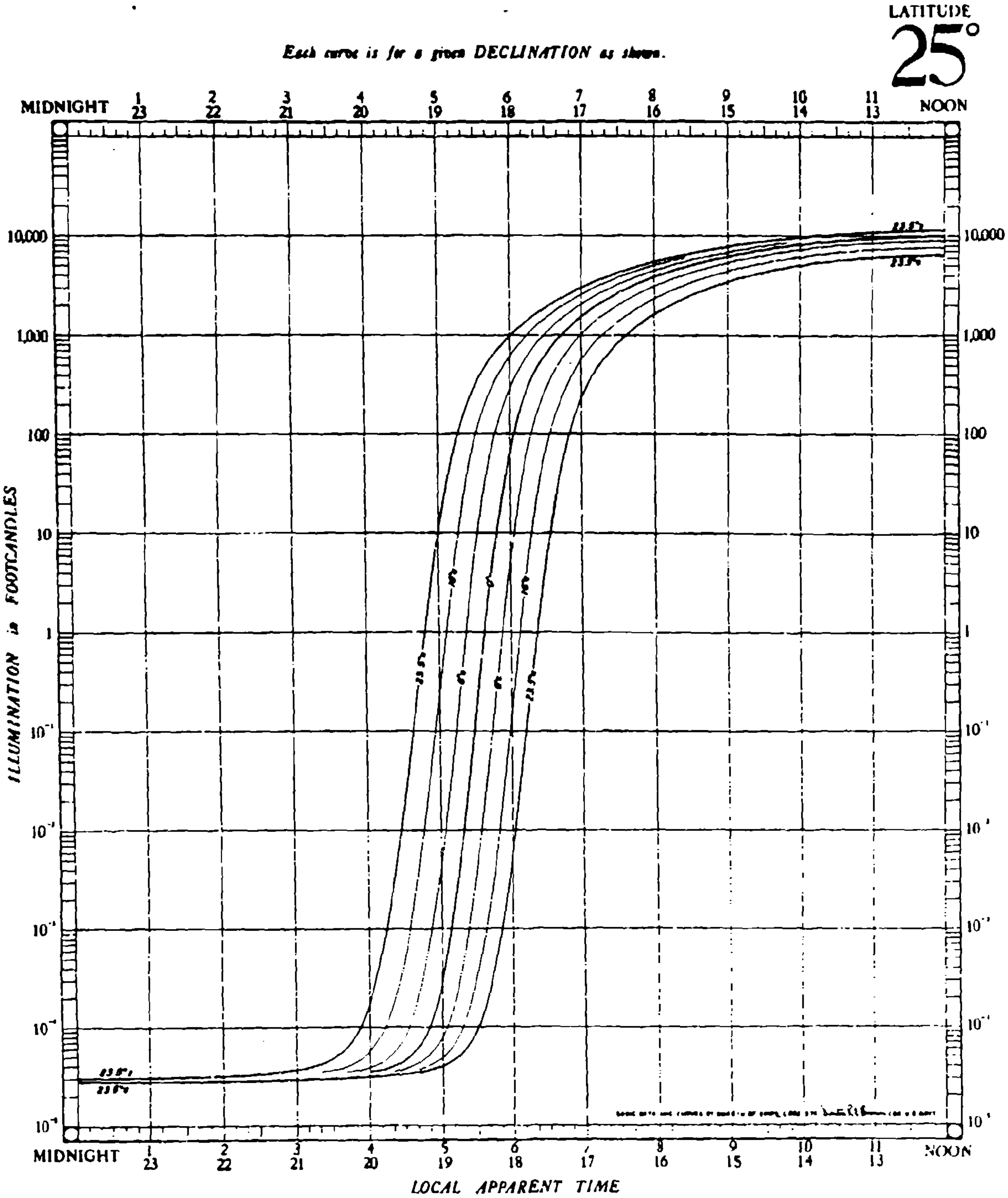
LATITUDE
0°

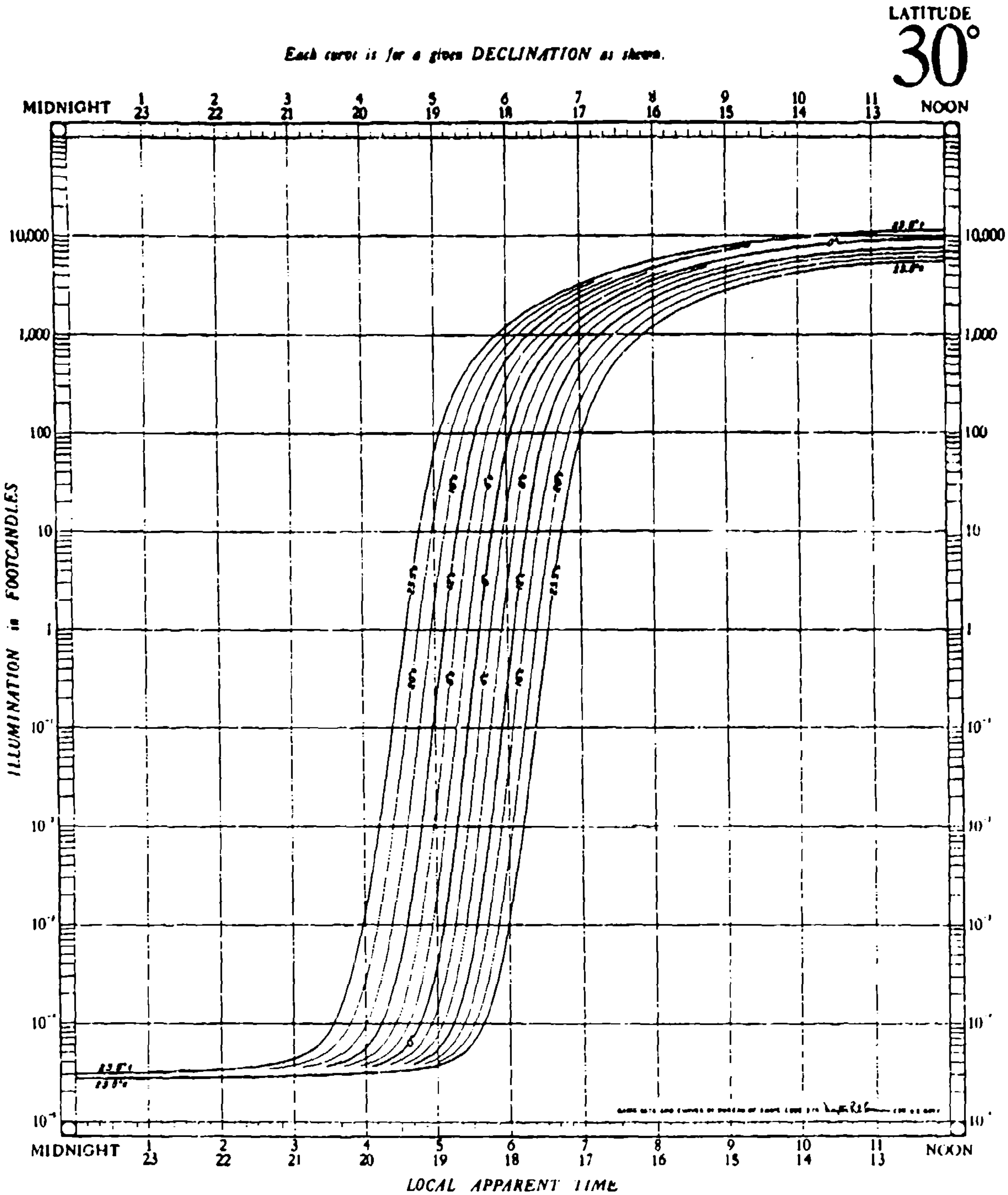
Each curve is for a given DECLINATION as shown.



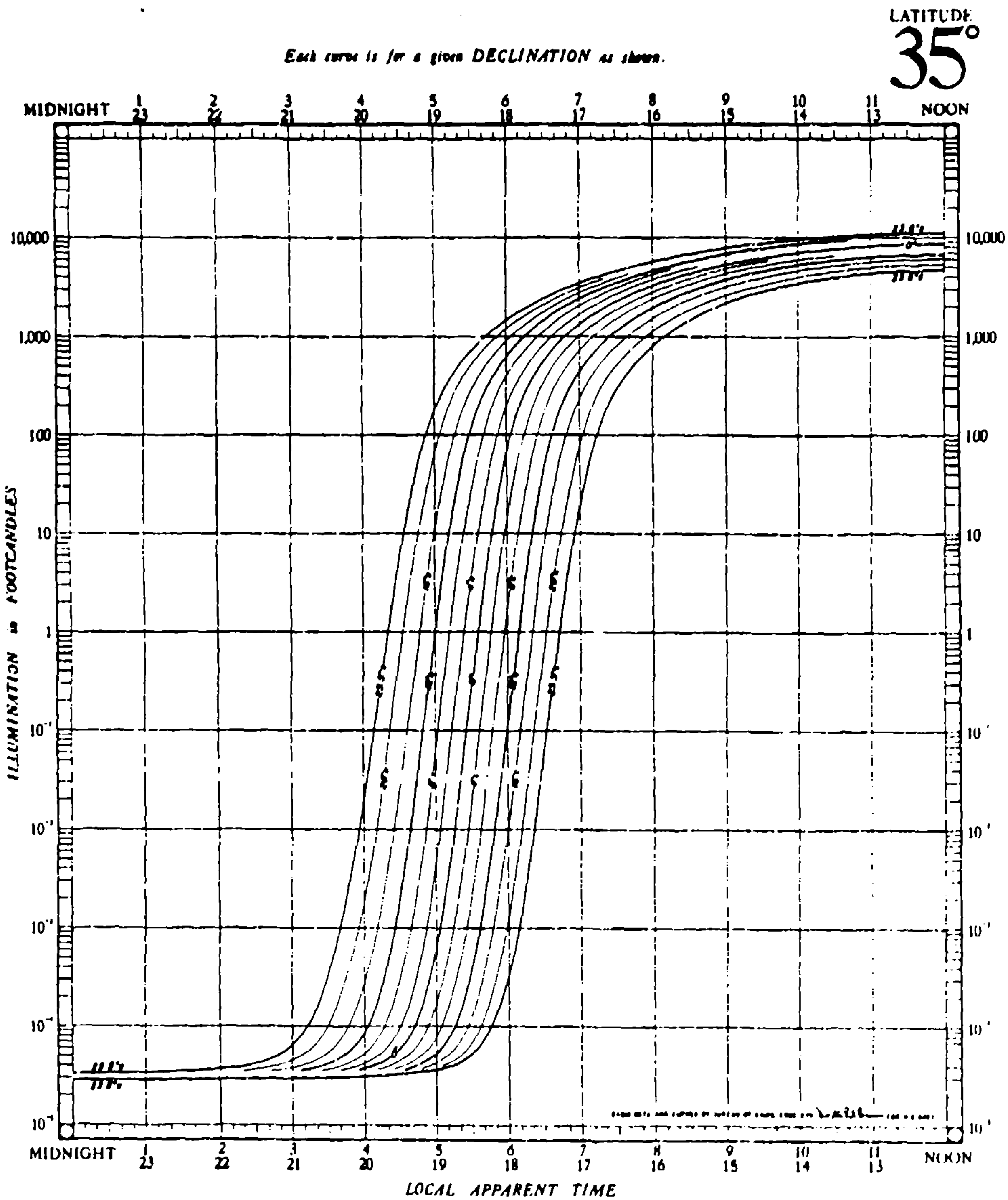

LATITUDE
10°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME


LATITUDE
20°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
10,000
1,000
100
10
1
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME

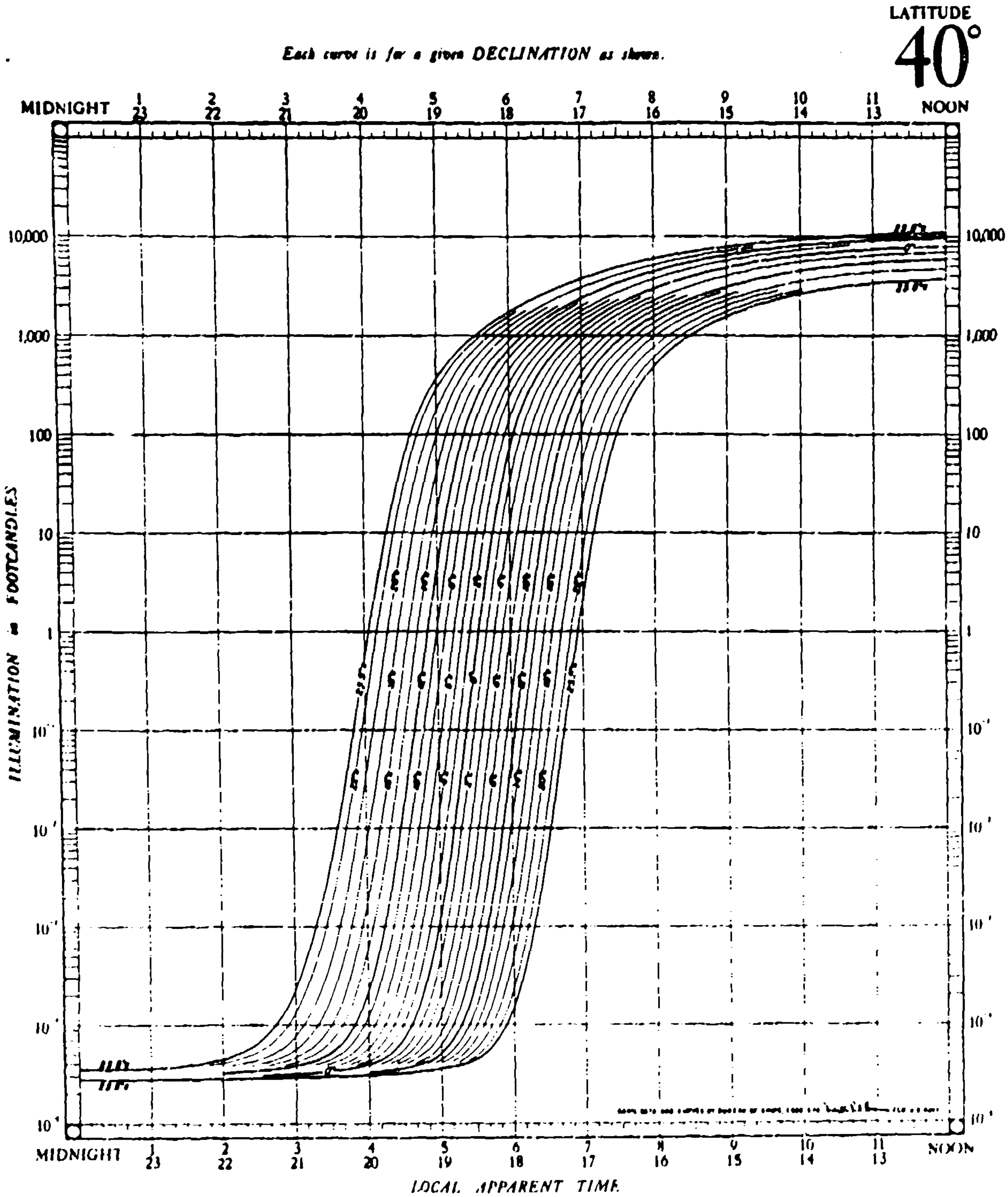

LATITUDE
25°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
1 23
2 22
3 21
4 20
5 19
6 18
7 17
8 16
9 15
10 14
11 13
10,000
1,000
100
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME

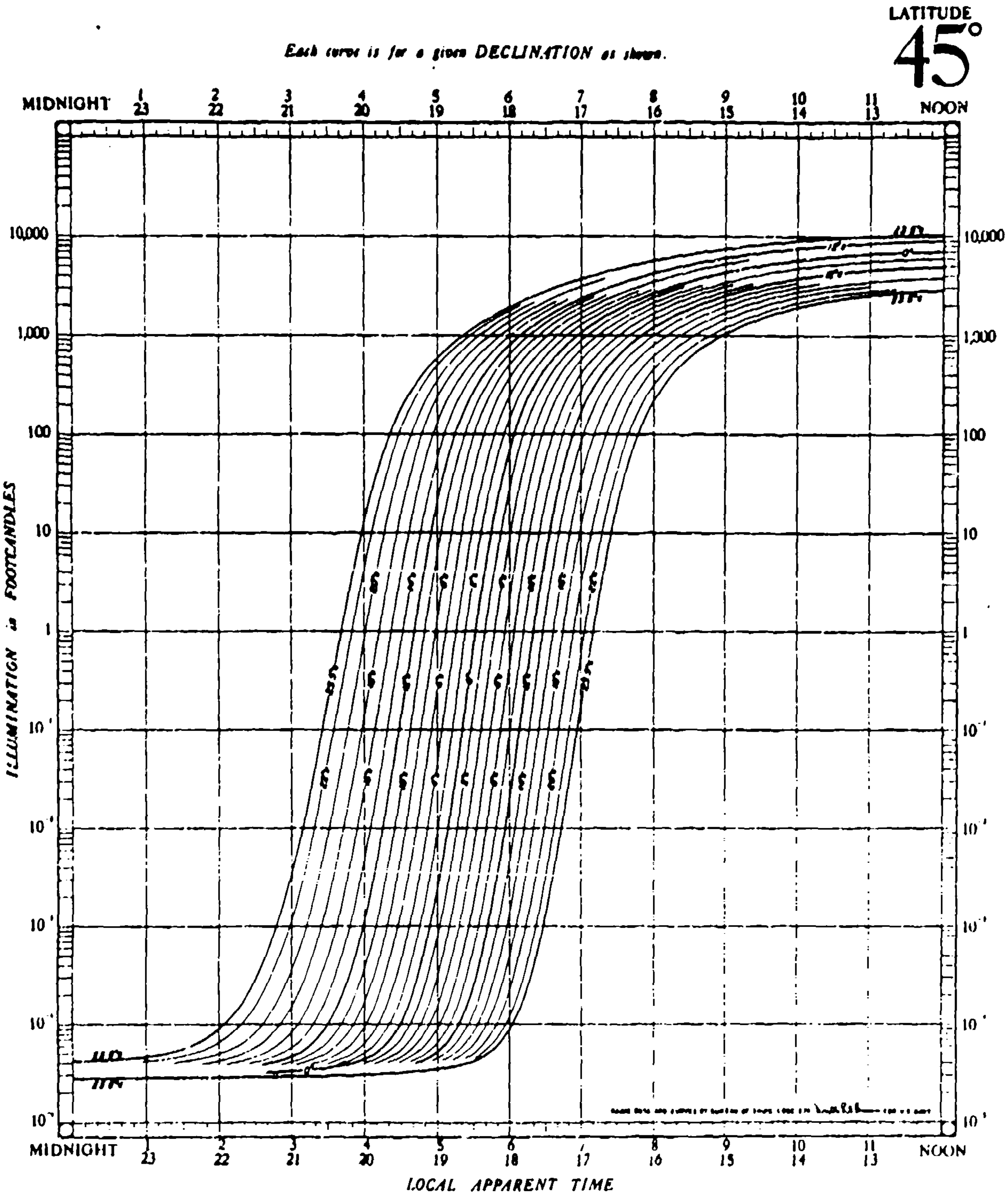


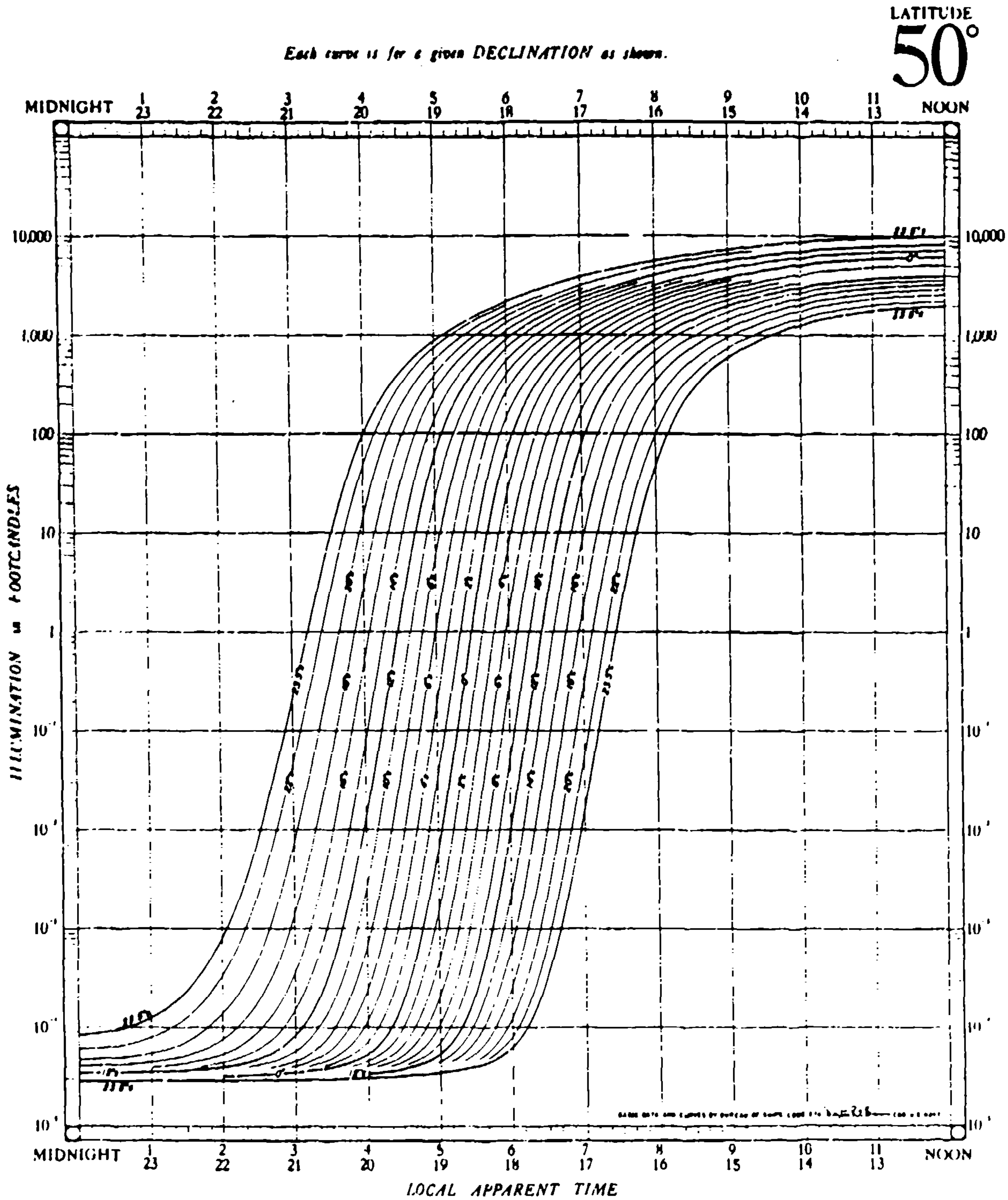
LATITUDE
30°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
1 23
2 22
3 21
4 20
5 19
6 18
7 17
8 16
9 15
10 14
11 13
10,000
1,000
100
10
1
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME



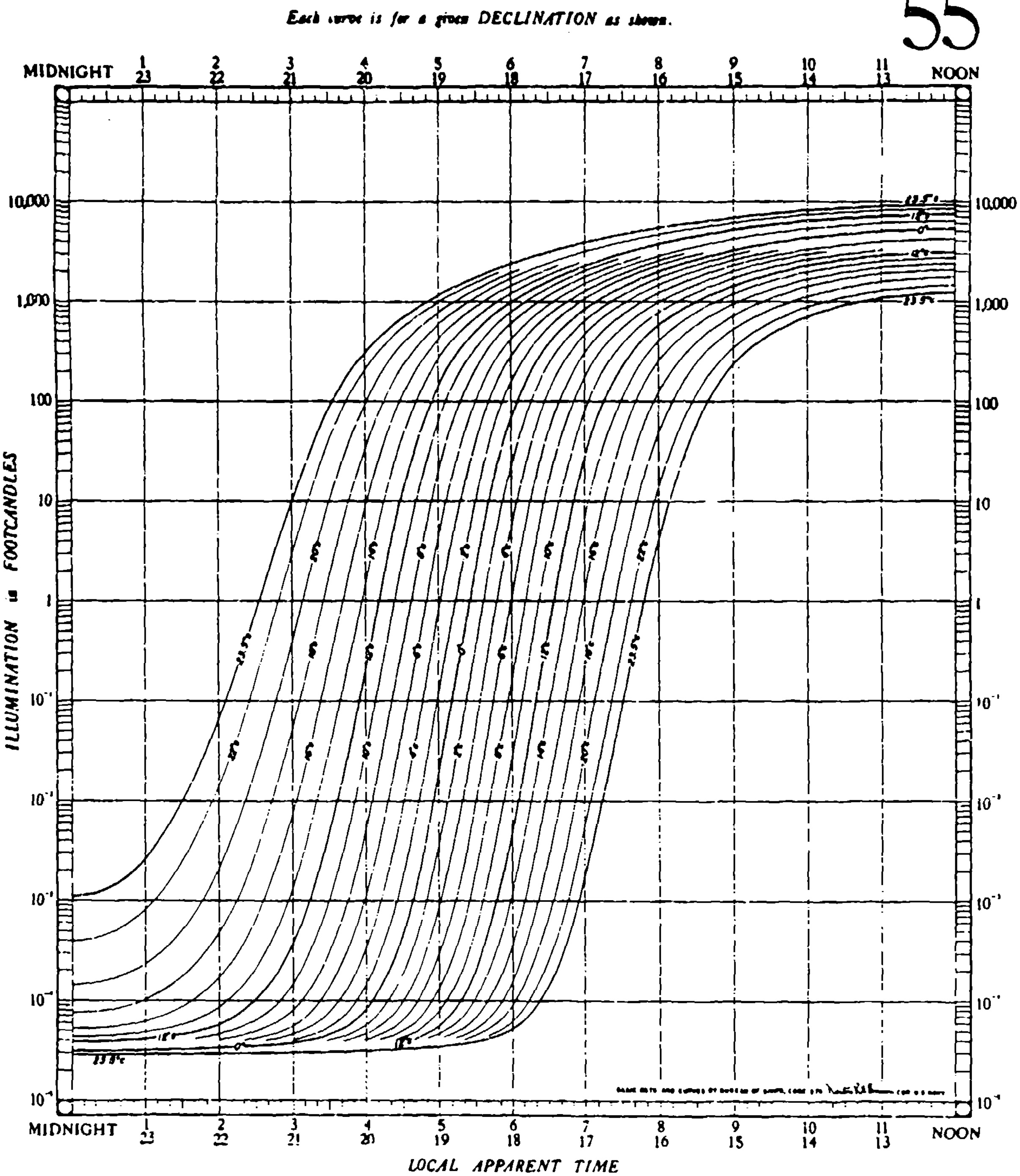
LATITUDE
35°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
10,000
1,000
100
10
1
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME


LATITUDE
40°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION = FOOTCANDLES
10,000
1,000
100
10
1
LOCAL APPARENT TIME

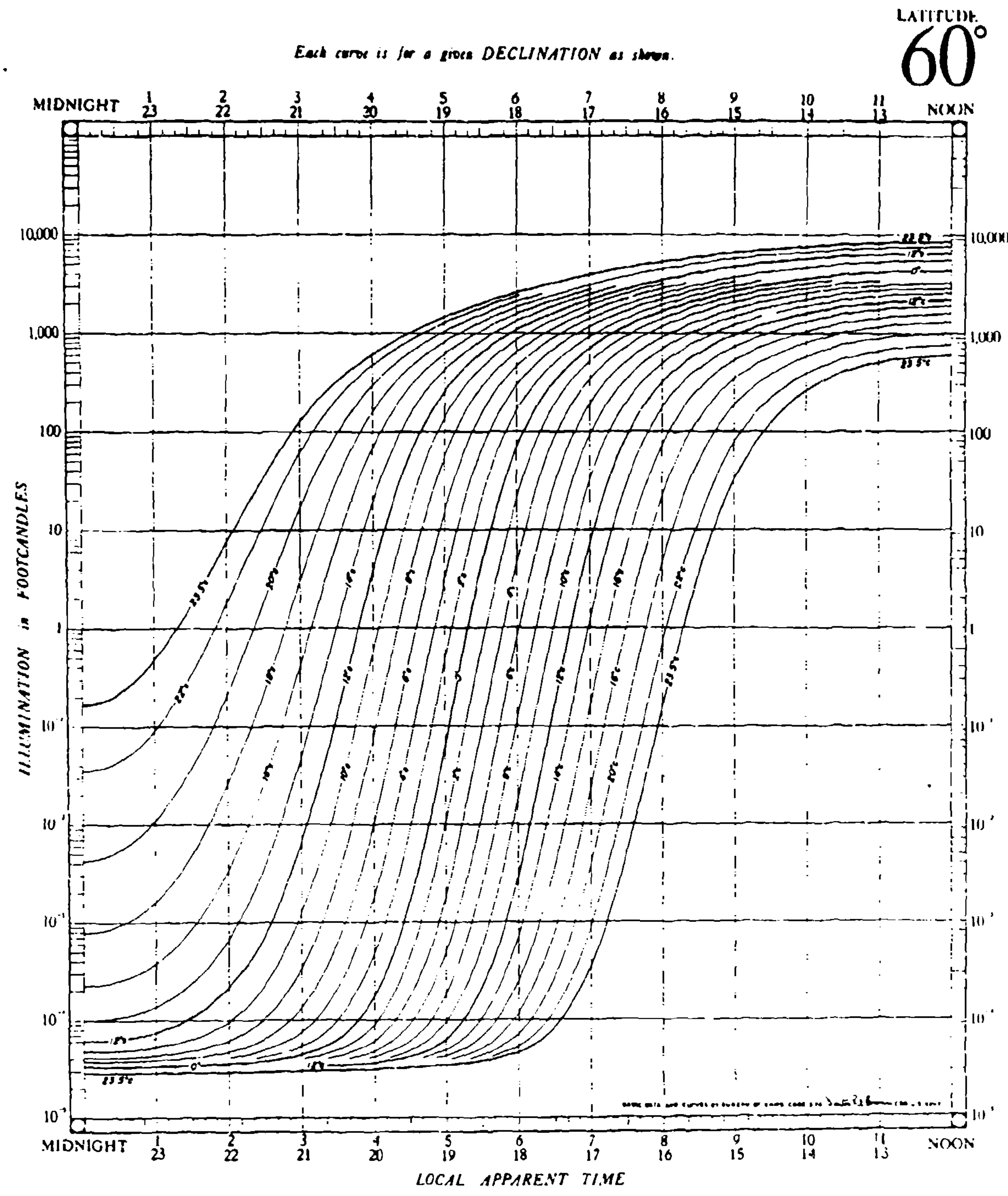

LATITUDE
45°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME
10,000
1,000
100
10
1


LATITUDE
50°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME
10,000
1,000
100
10
1

LATITUDE 55°

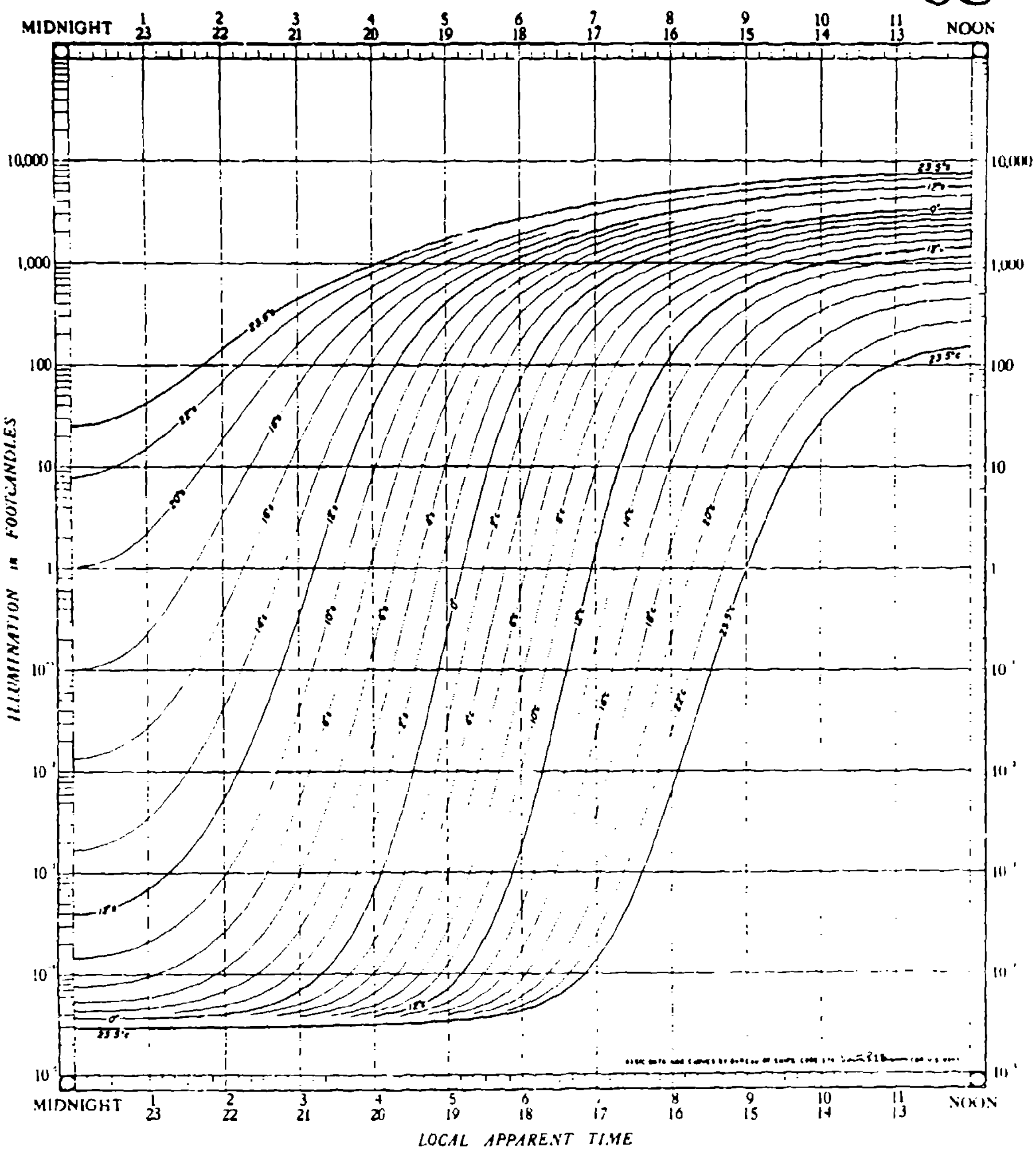


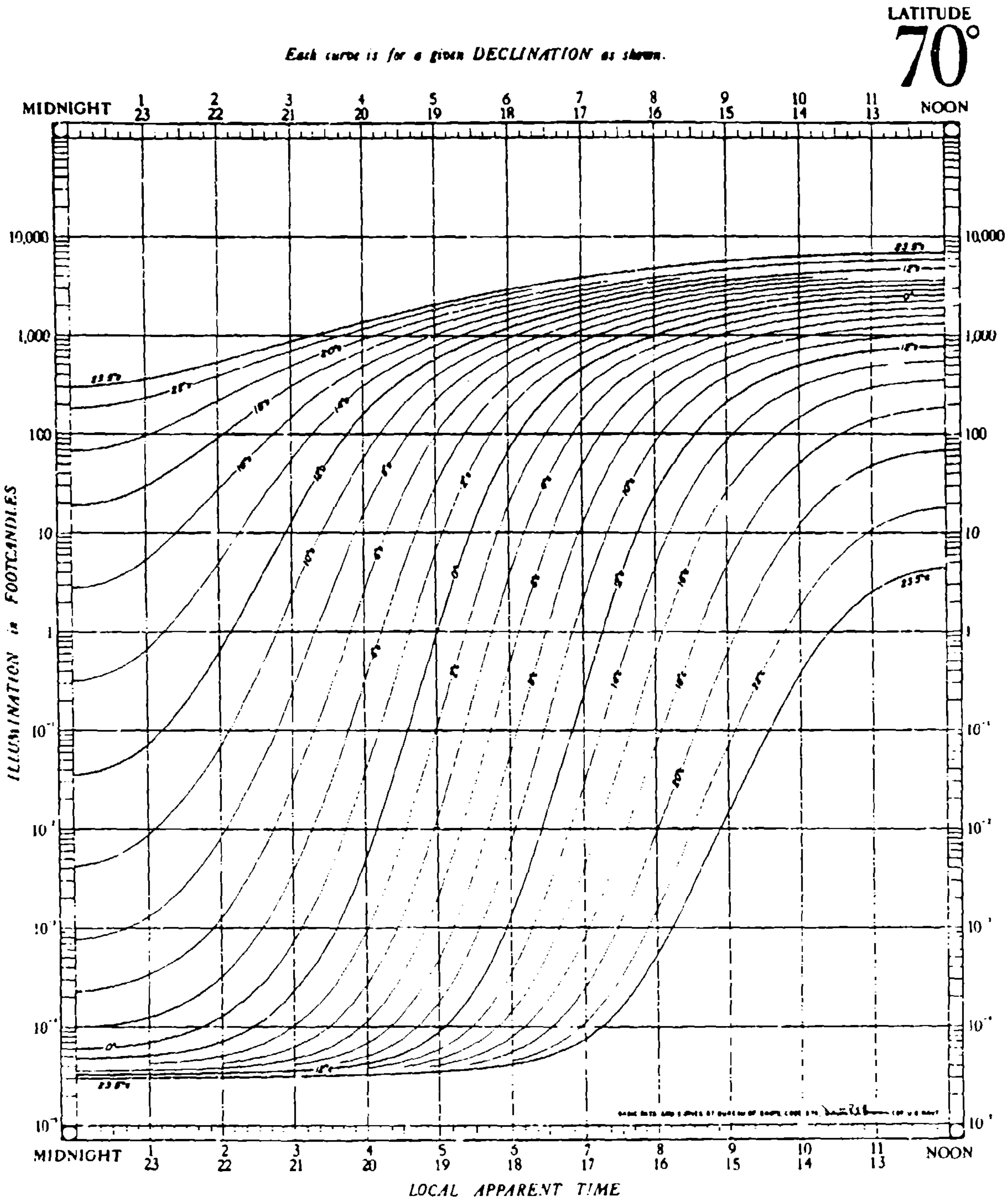
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
1 23
2 22
3 21
4 20
5 19
6 18
7 17
8 16
9 15
10 14
11 13
10,000
1,000
100
10
1
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME


LATITUDE
60°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME
10,000
1,000
100
10
1

LATITUDE 65°

Each curve is for a given DECLINATION as shown.

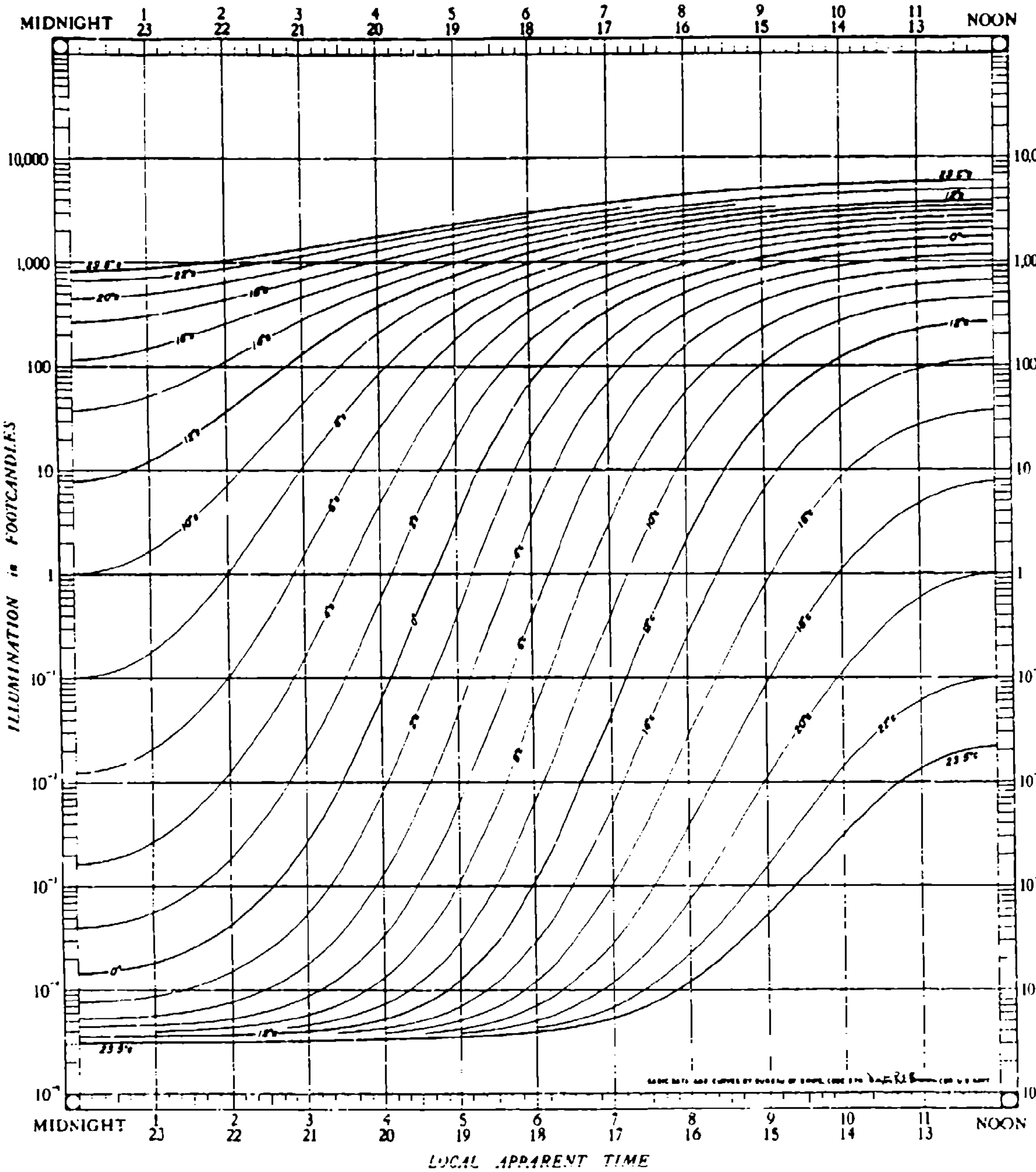




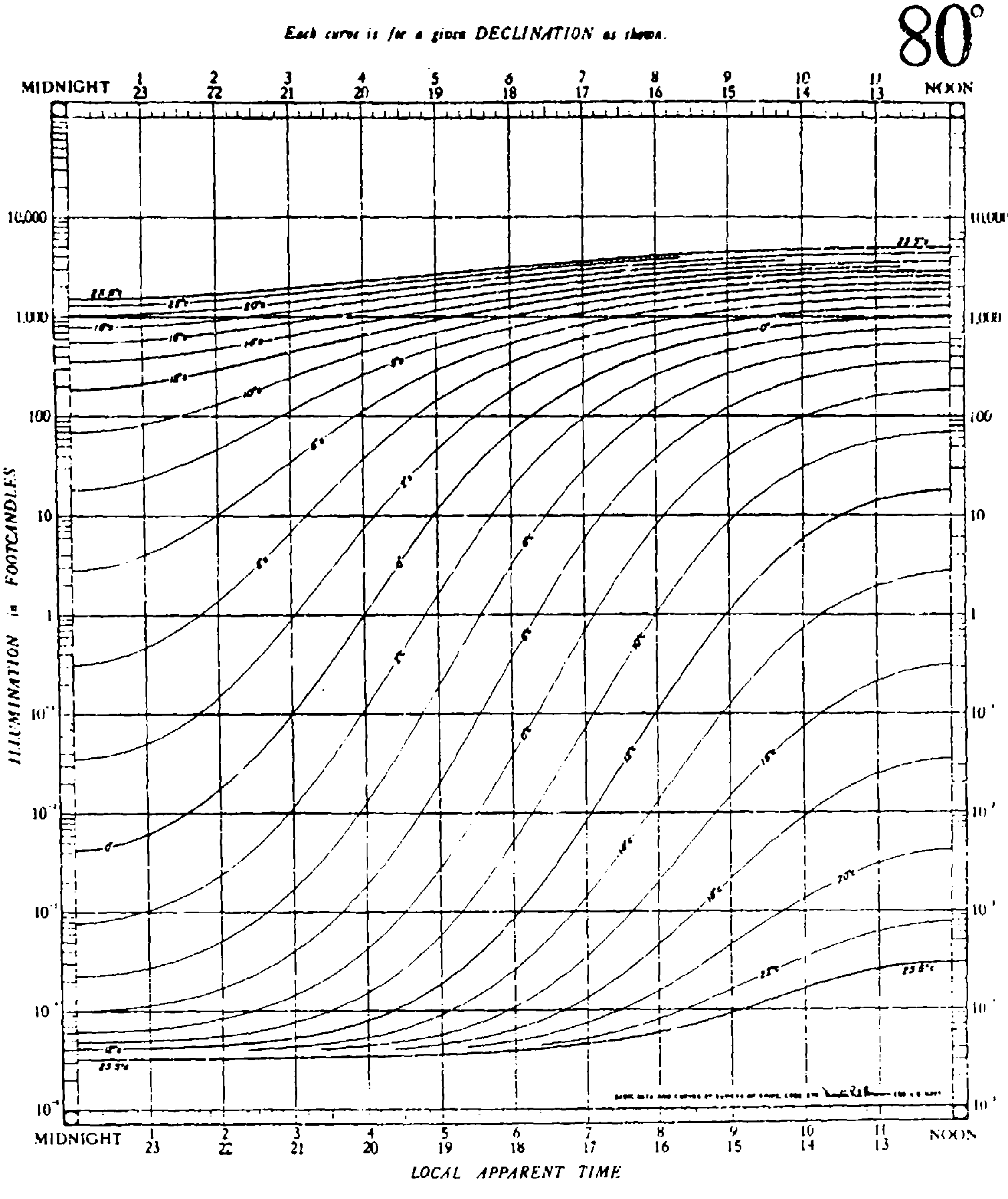
LATITUDE
70°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME

LATITUDE
75°

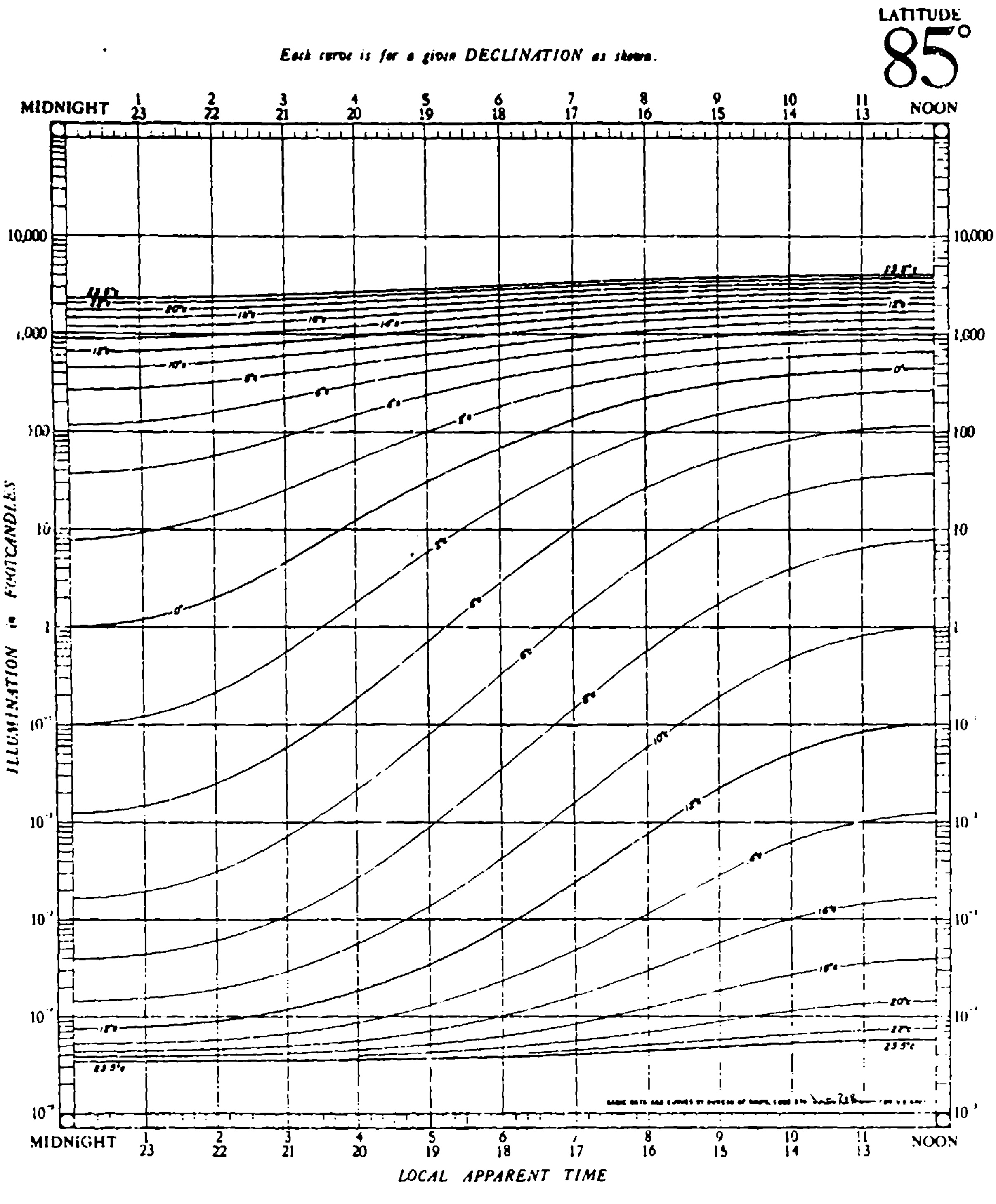
Each curve is for a given DECLINATION as shown.

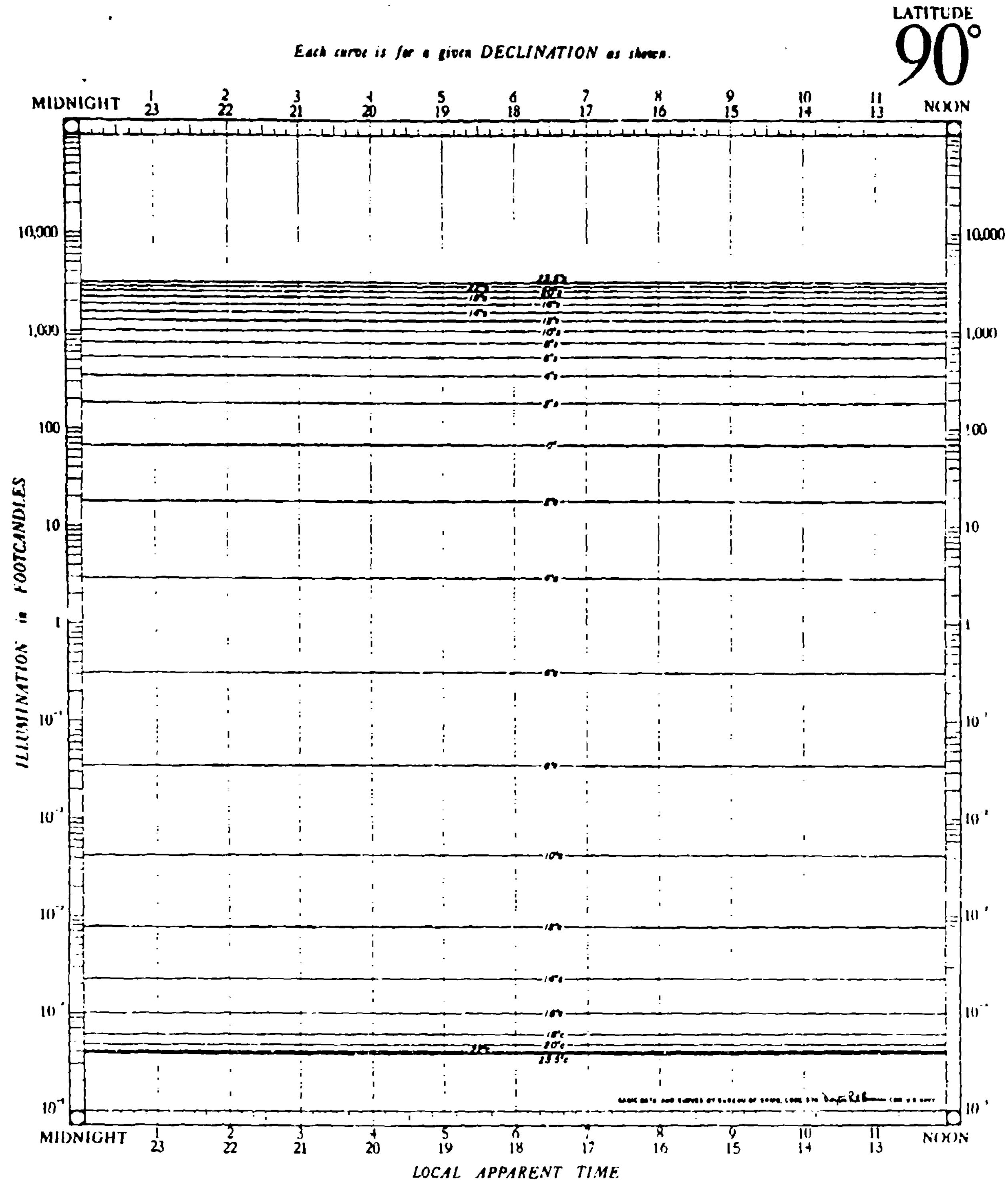


LATITUDE 80°



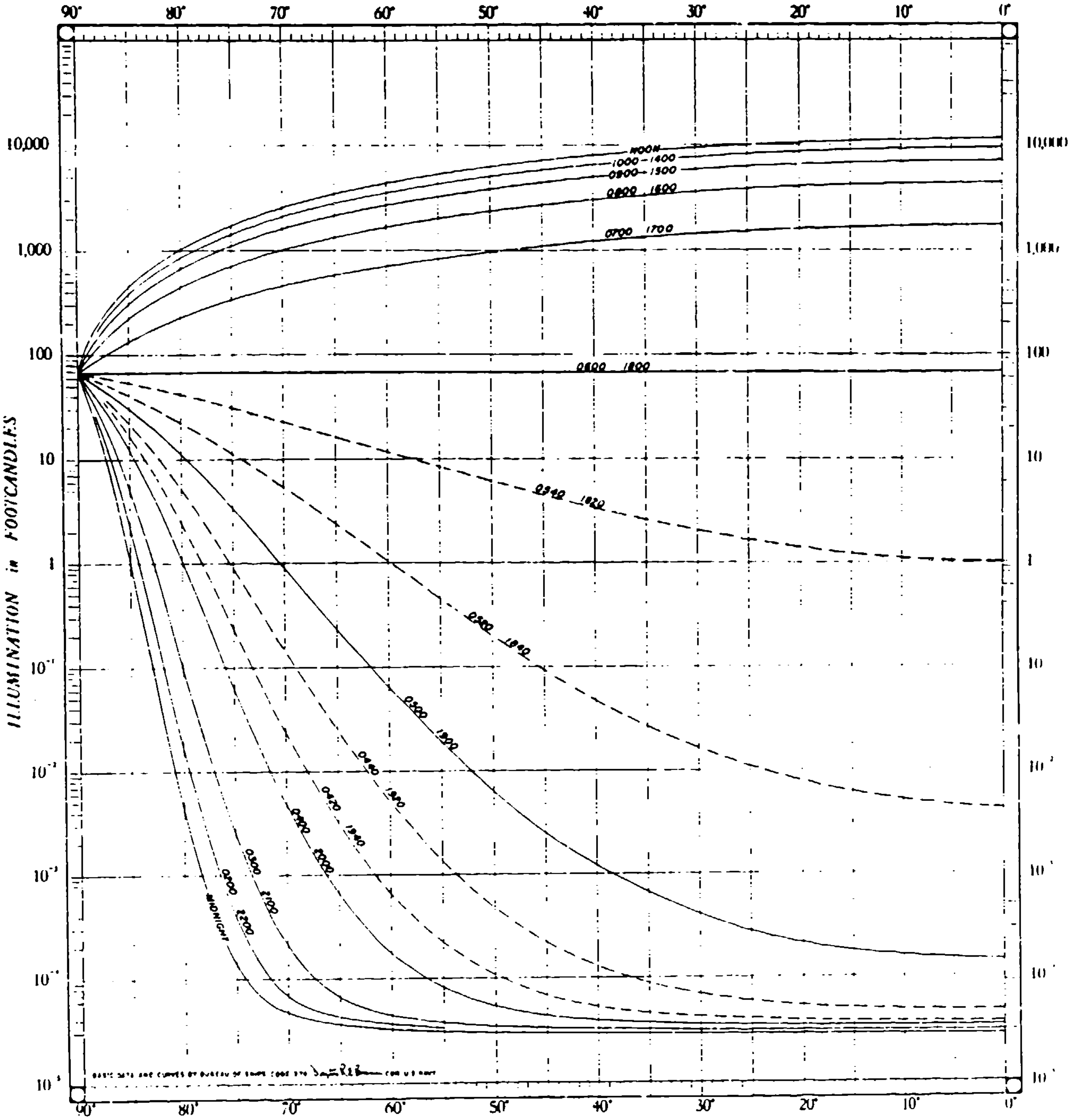
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
10,000
1,000
100
10
1
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME


LATITUDE
85°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
1 23
2 22
3 21
4 20
5 19
6 18
7 17
8 16
9 15
10 14
11 13
NOON
ILLUMINATION in FOOTCANDLES
10,000
1,000
100
10
1
LOCAL APPARENT TIME


LATITUDE
90°
Each curve is for a given DECLINATION as shown.
MIDNIGHT
NOON
ILLUMINATION in FOOTCANDLES
LOCAL APPARENT TIME

DECLINATION

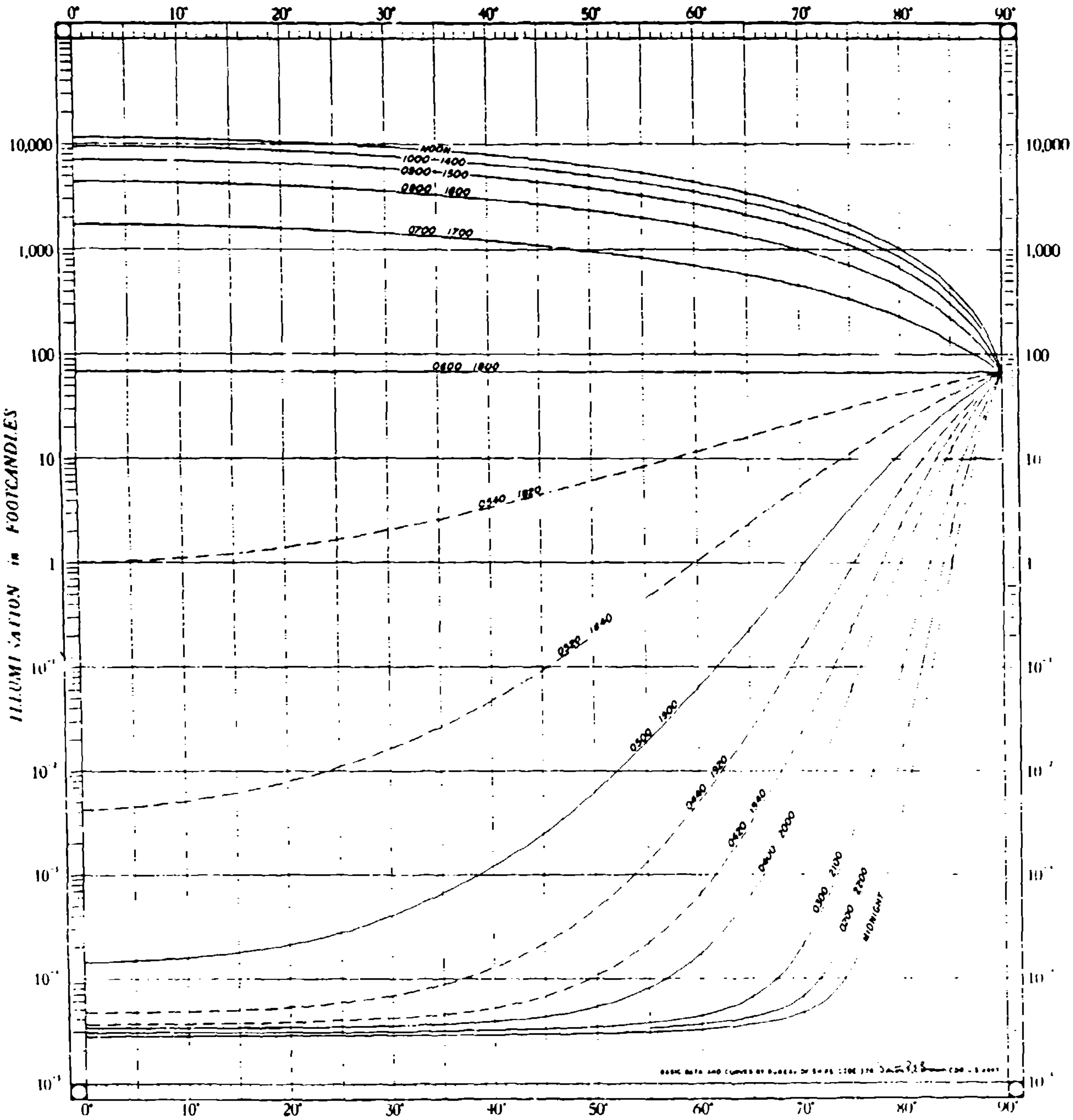
0° Latitude CONTRARY to declination



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

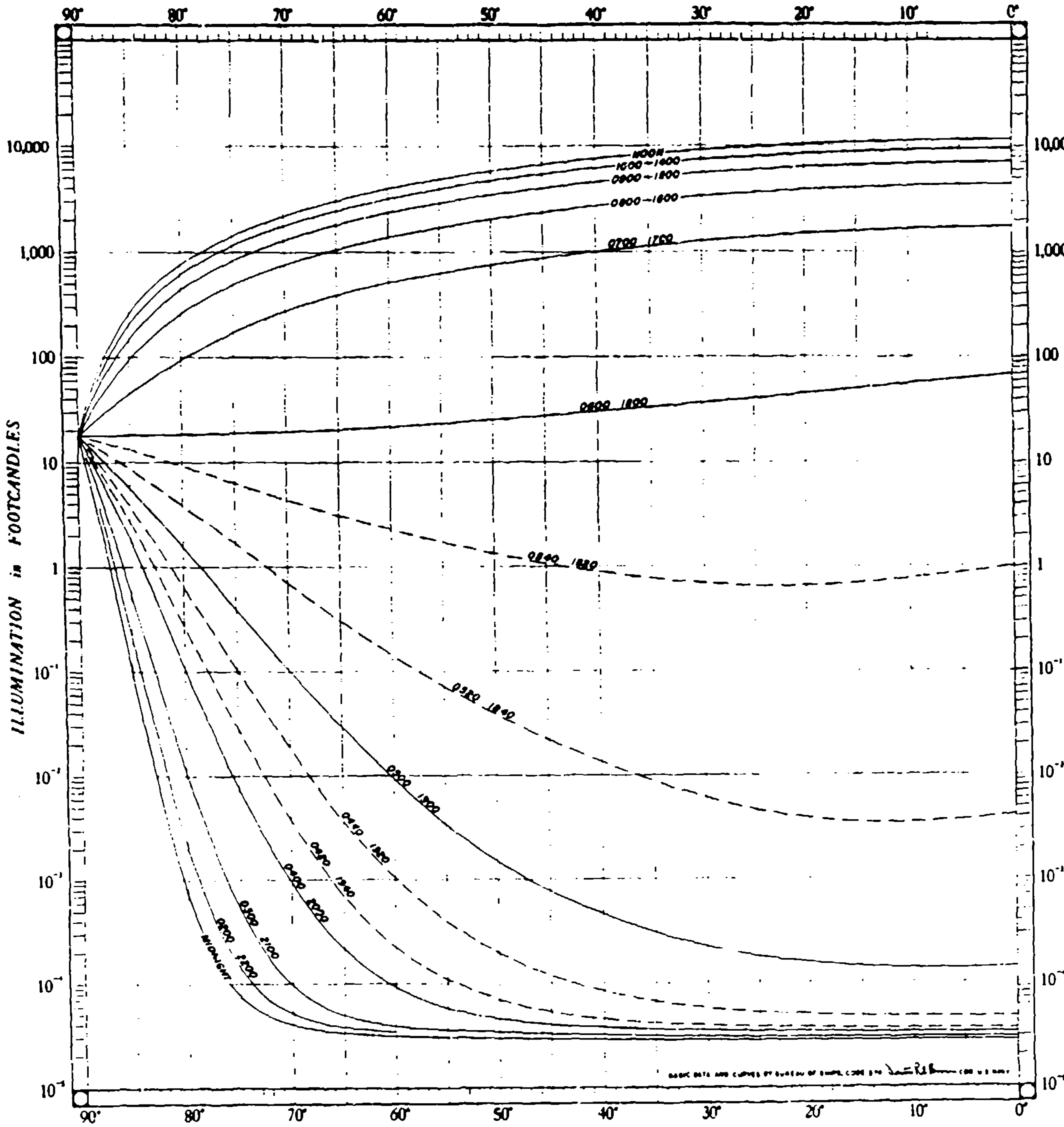
Latitude SAME as declination 0°



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

2° Latitude CONTRARY to declination

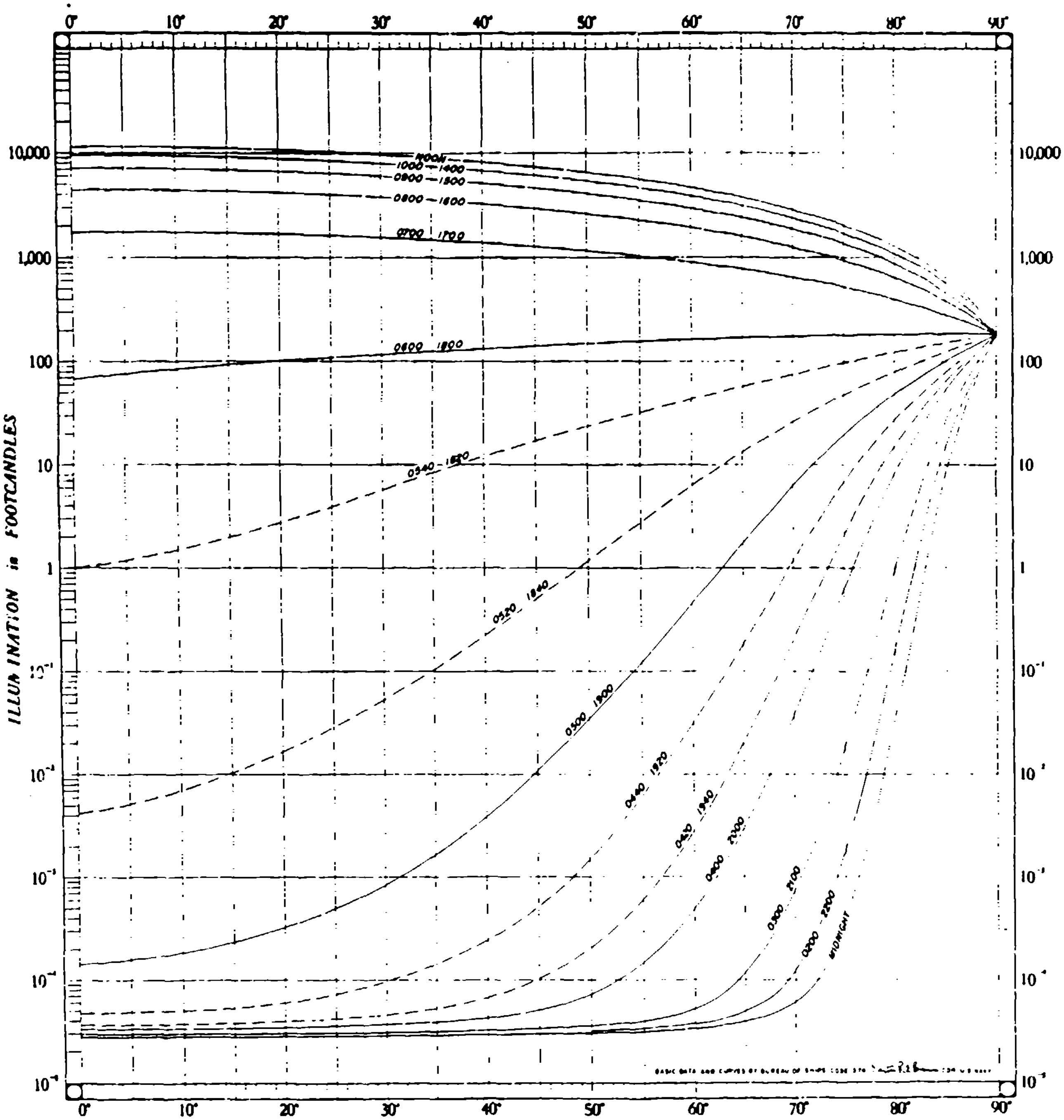


Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

2°

Latitude SAME as declination

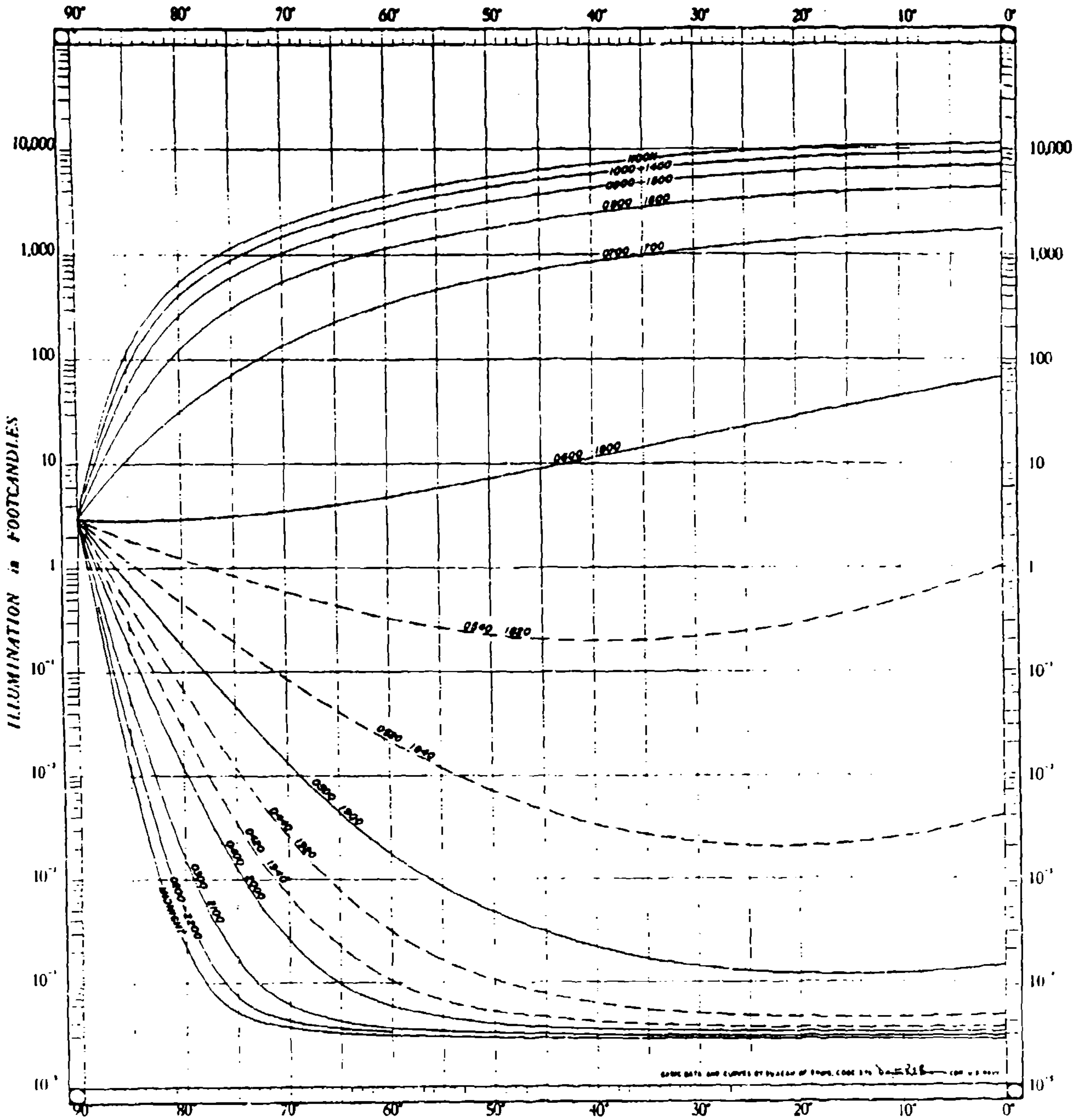


Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

4°

Latitude CONTRARY *to declination*



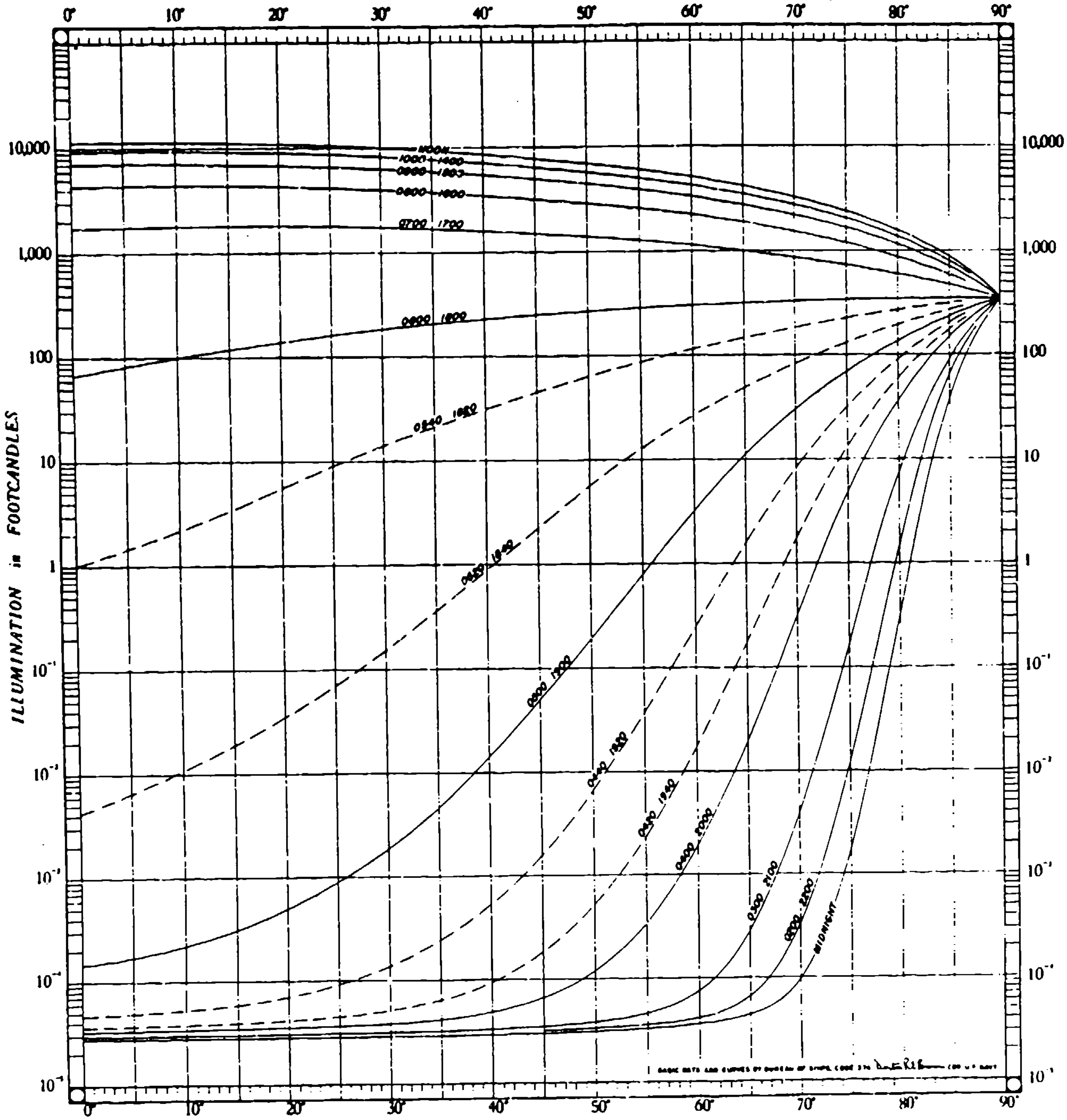
Each curve is for a given hour of LOCAL APPARENT TIME as shown.

22

DECLINATION

4°

Latitude SAME as declination

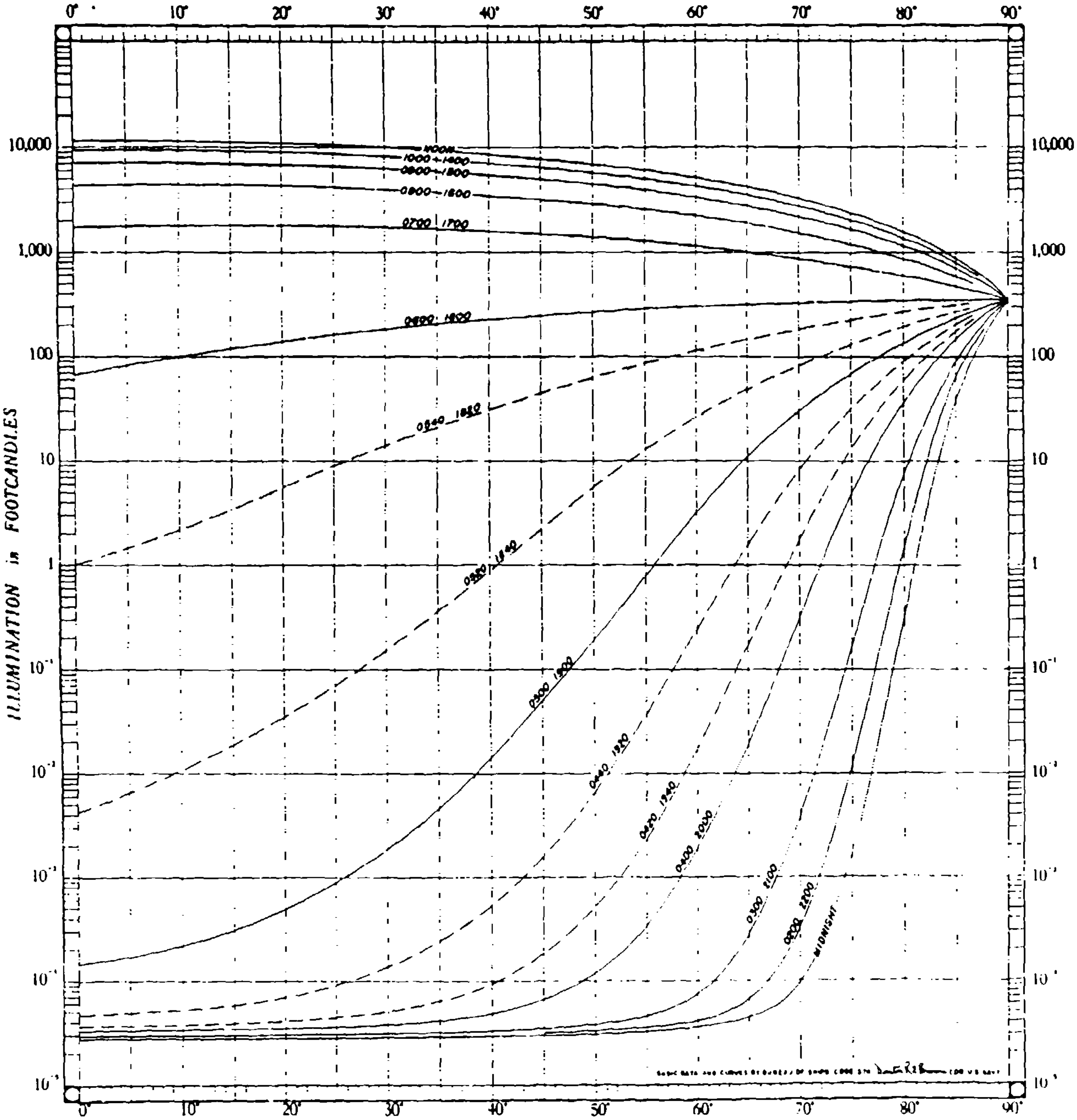


Each curve is for a given hour of LOCAL APPARENT TIME as shown.

PLATE 23

DECLINATION **4°**

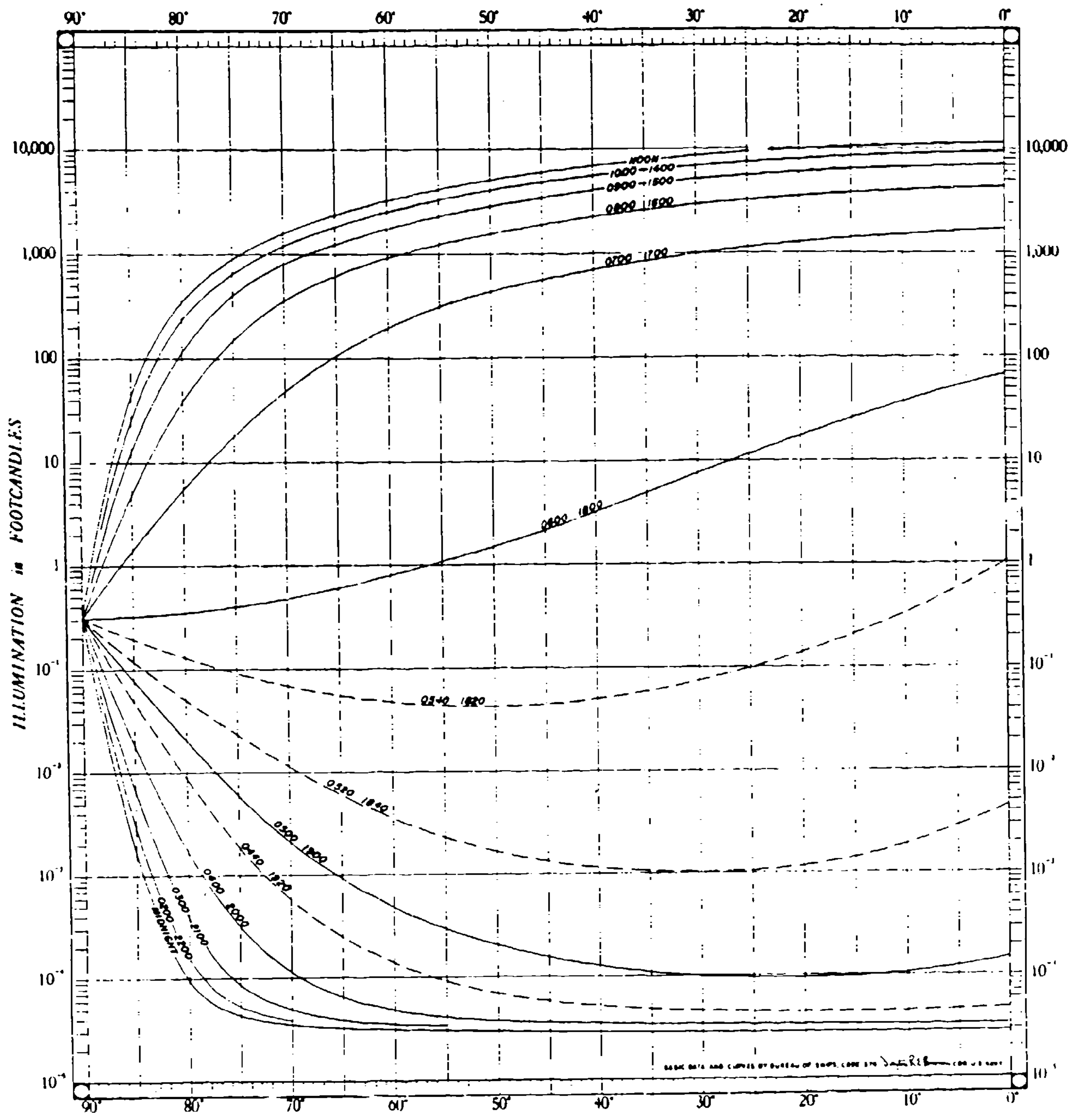
Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

PLATE 23

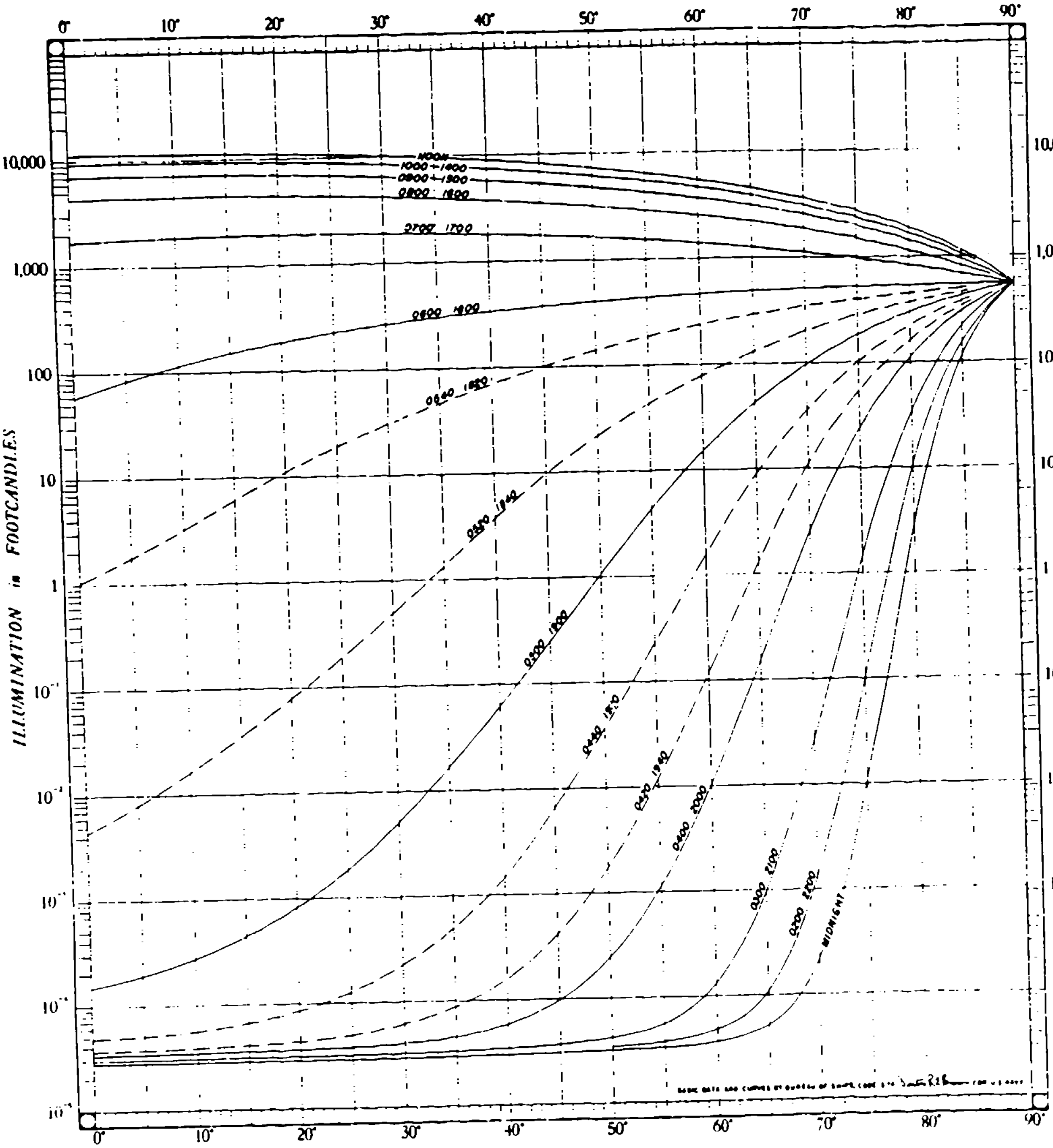
DECLINATION
6° *Latitude* CONTRARY *to declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION 6°

Latitude SAME as declination

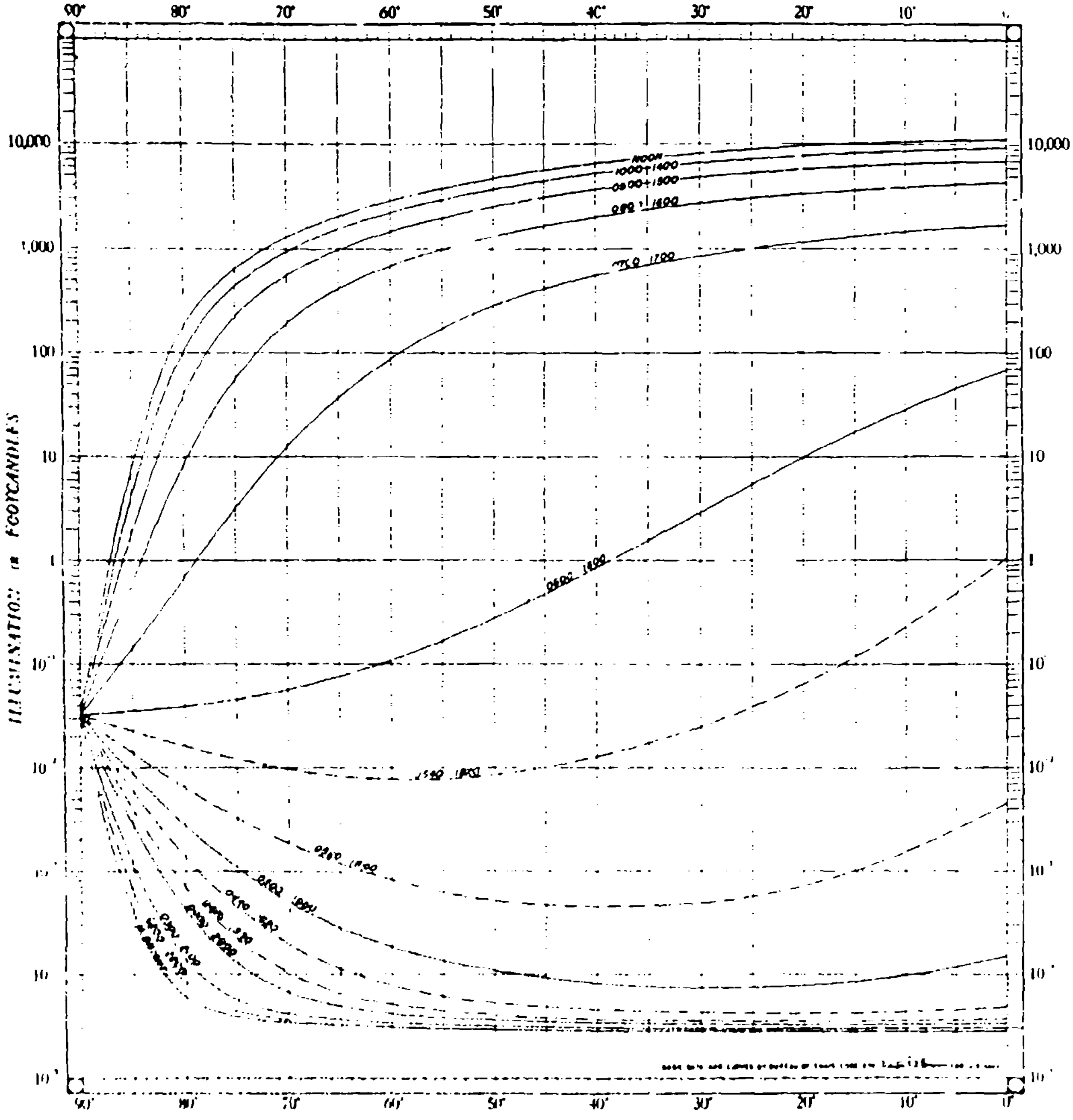


Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

8°

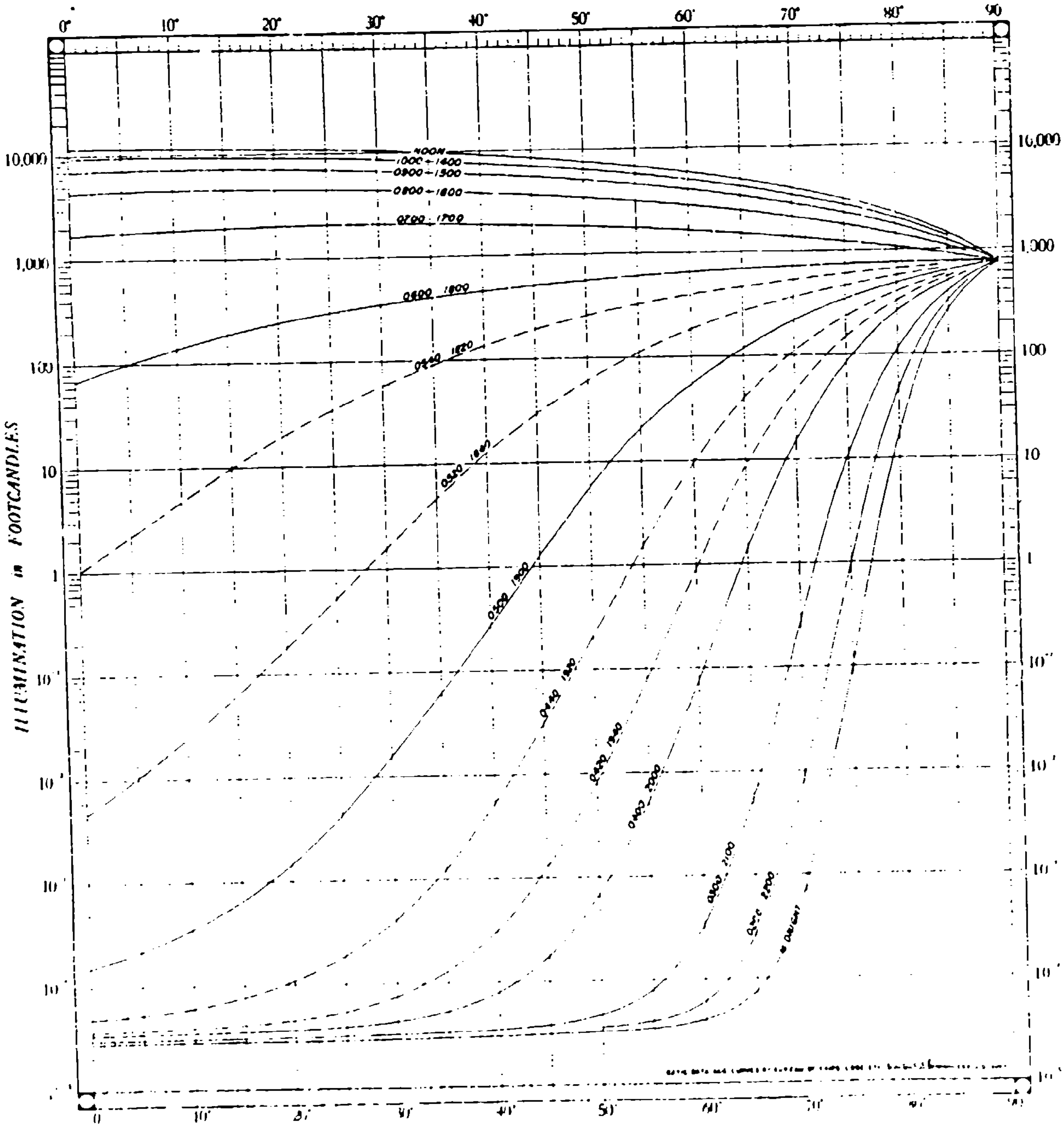
Latitude CONTRARY *to declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown

DECLINATION 8°

Latitude SAME *as declination*

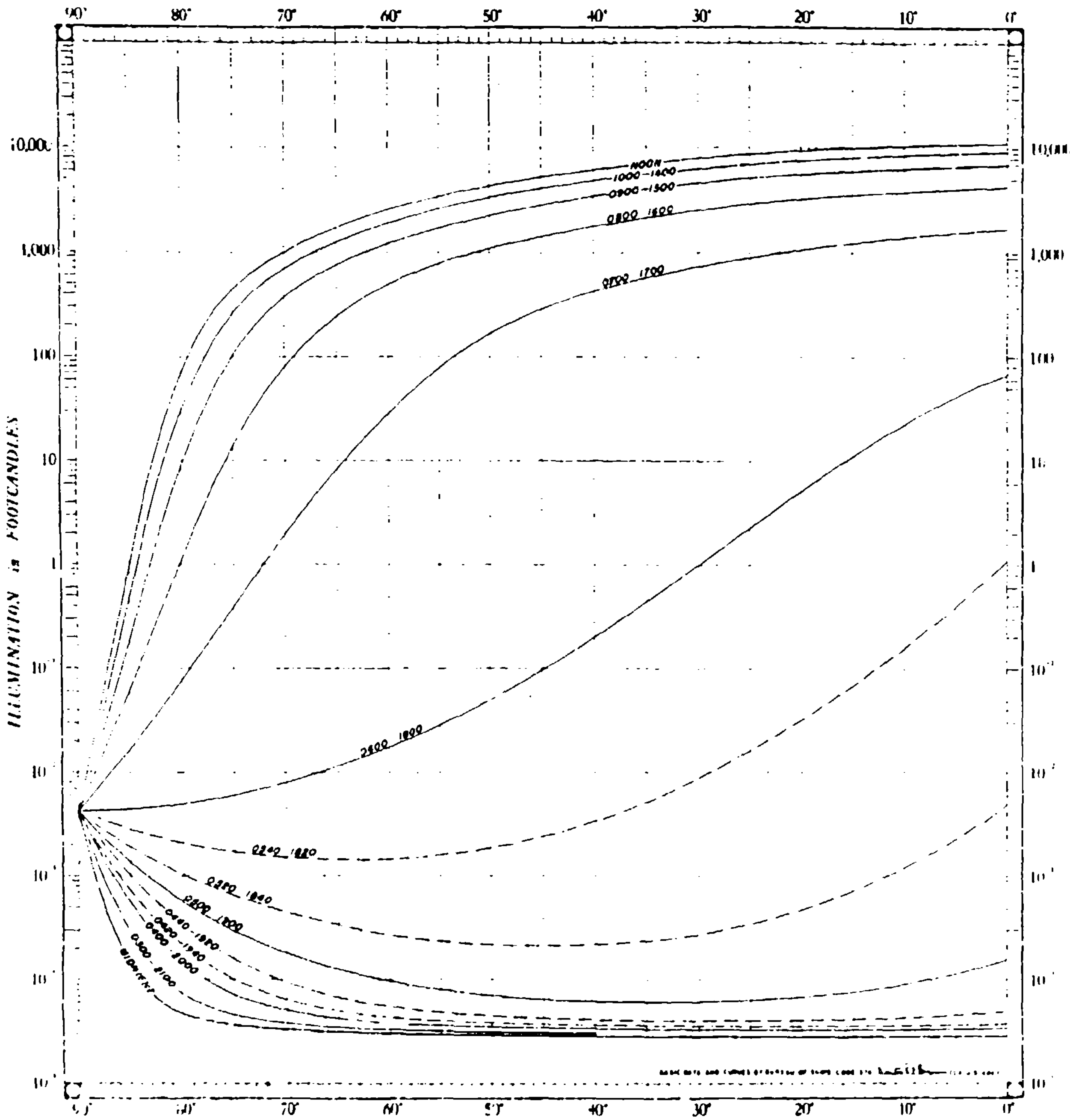


Each curve is for a given hour of LOCAL APPARENT TIME, as shown

DECLINATION

10°

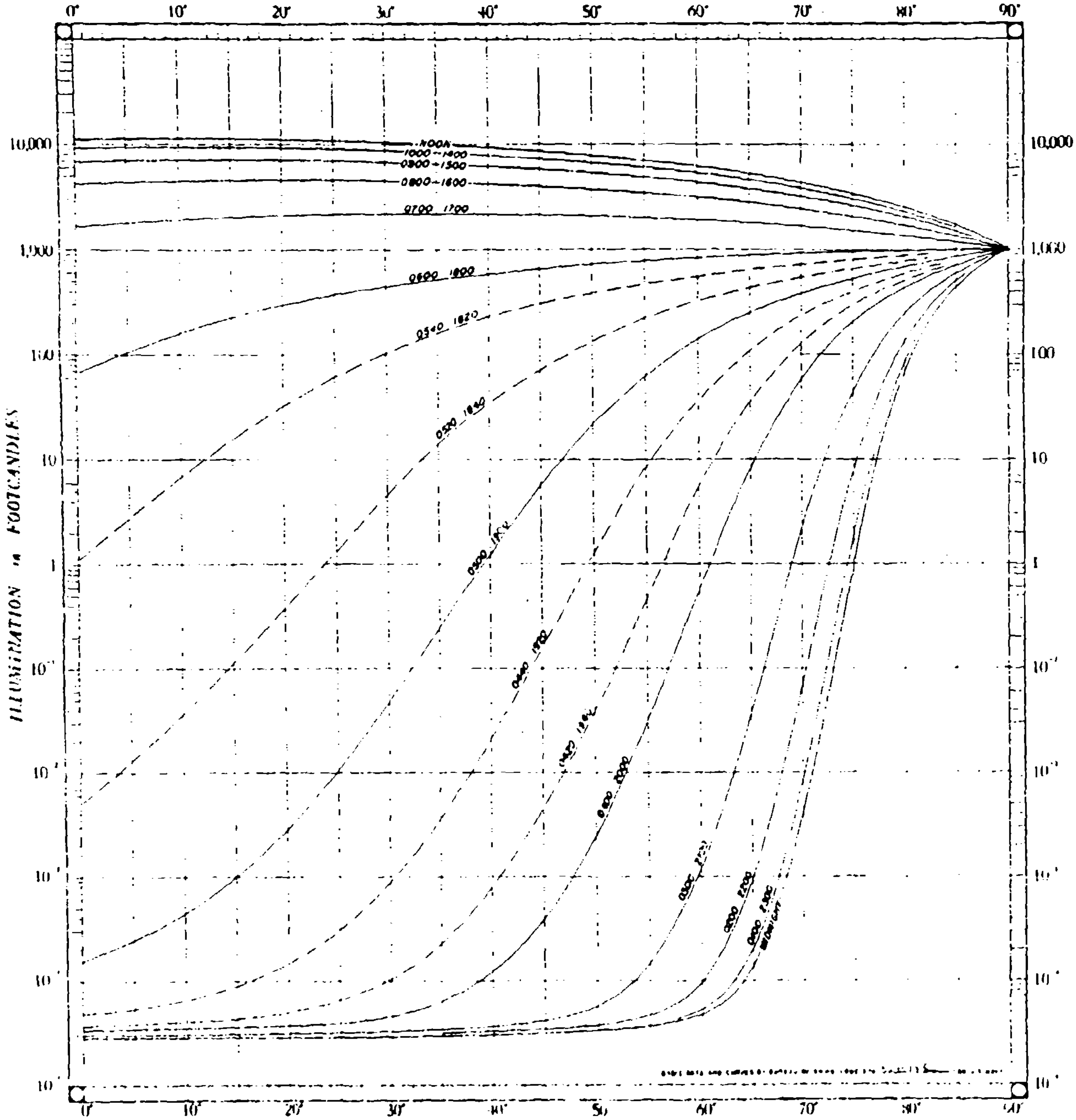
Latitude CONTRARY *to declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION
10°

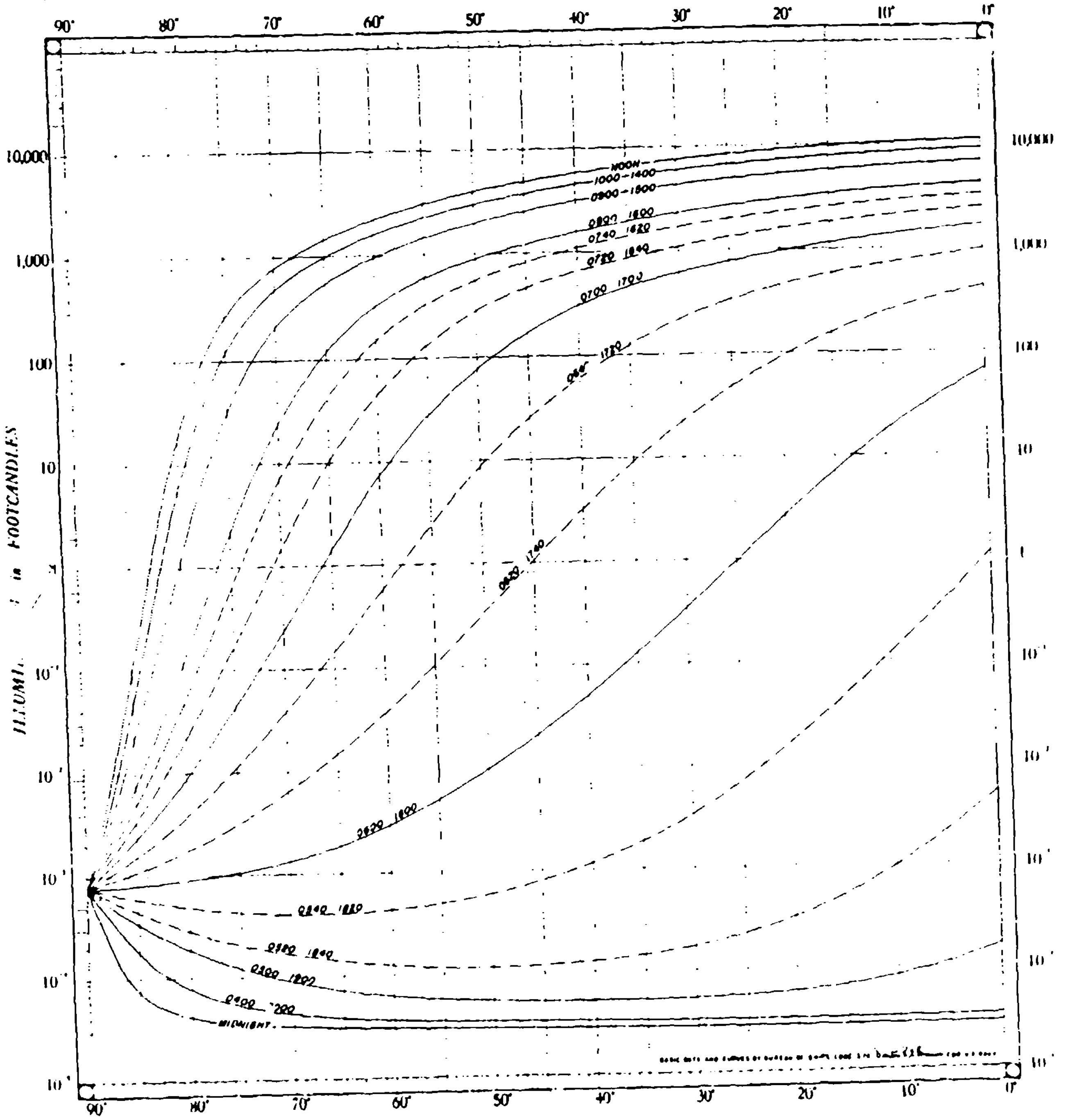
Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown

DECLINATION

12° *Latitude* CONTRARY *to declination*

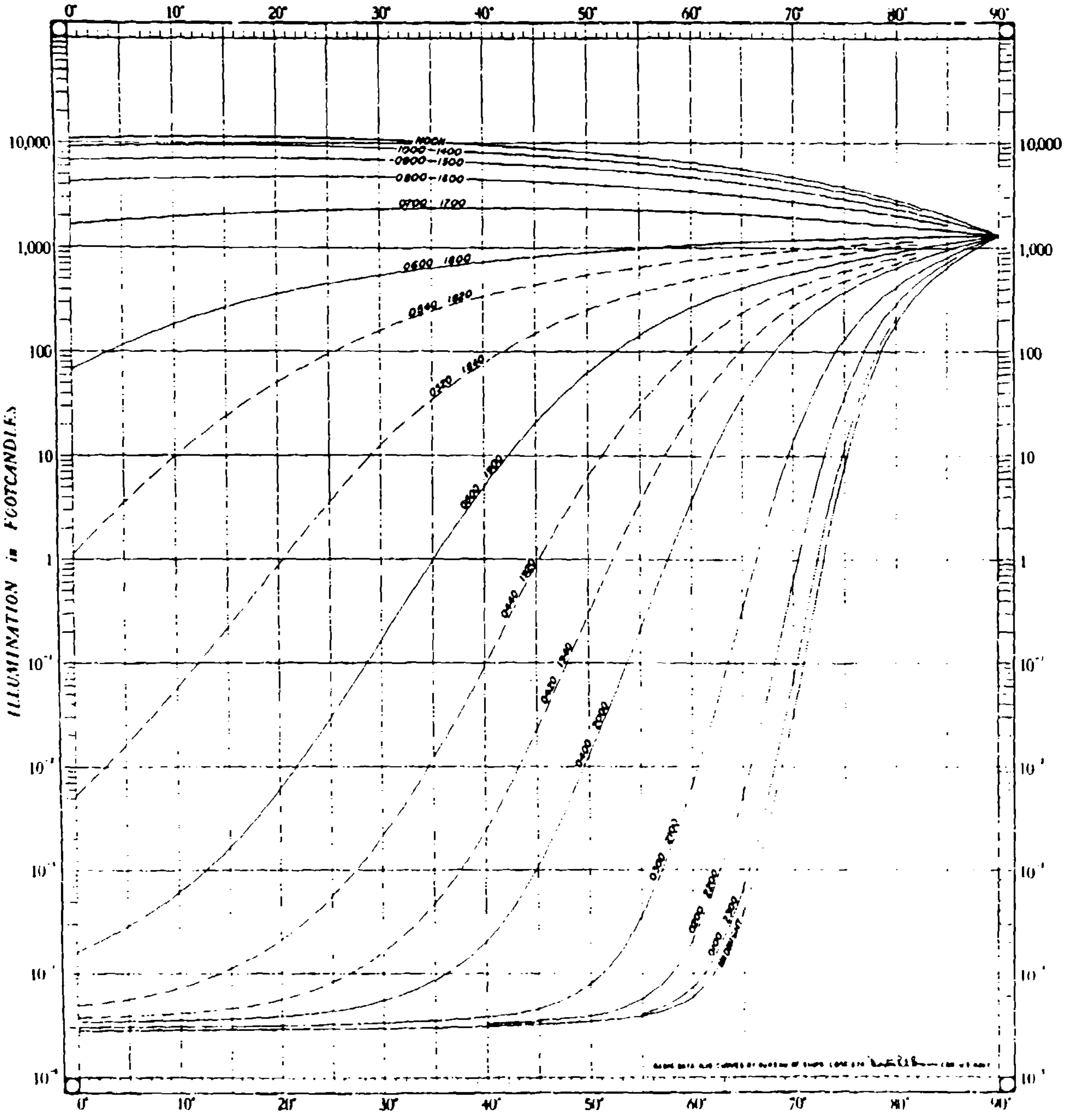


Each curve is for a given hour of LOCAL APPARENT TIME as shown

DECLINATION

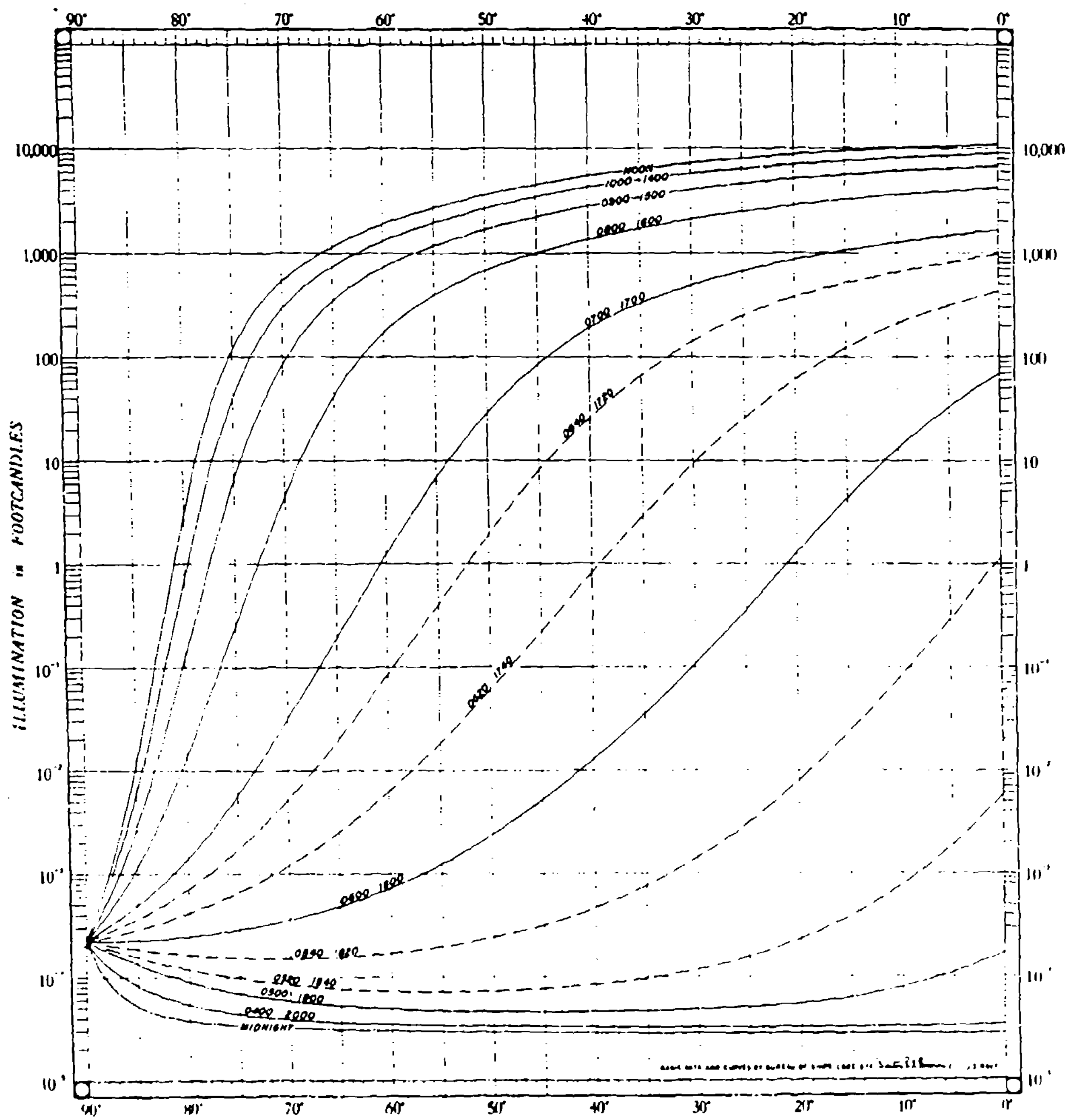
12°

Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

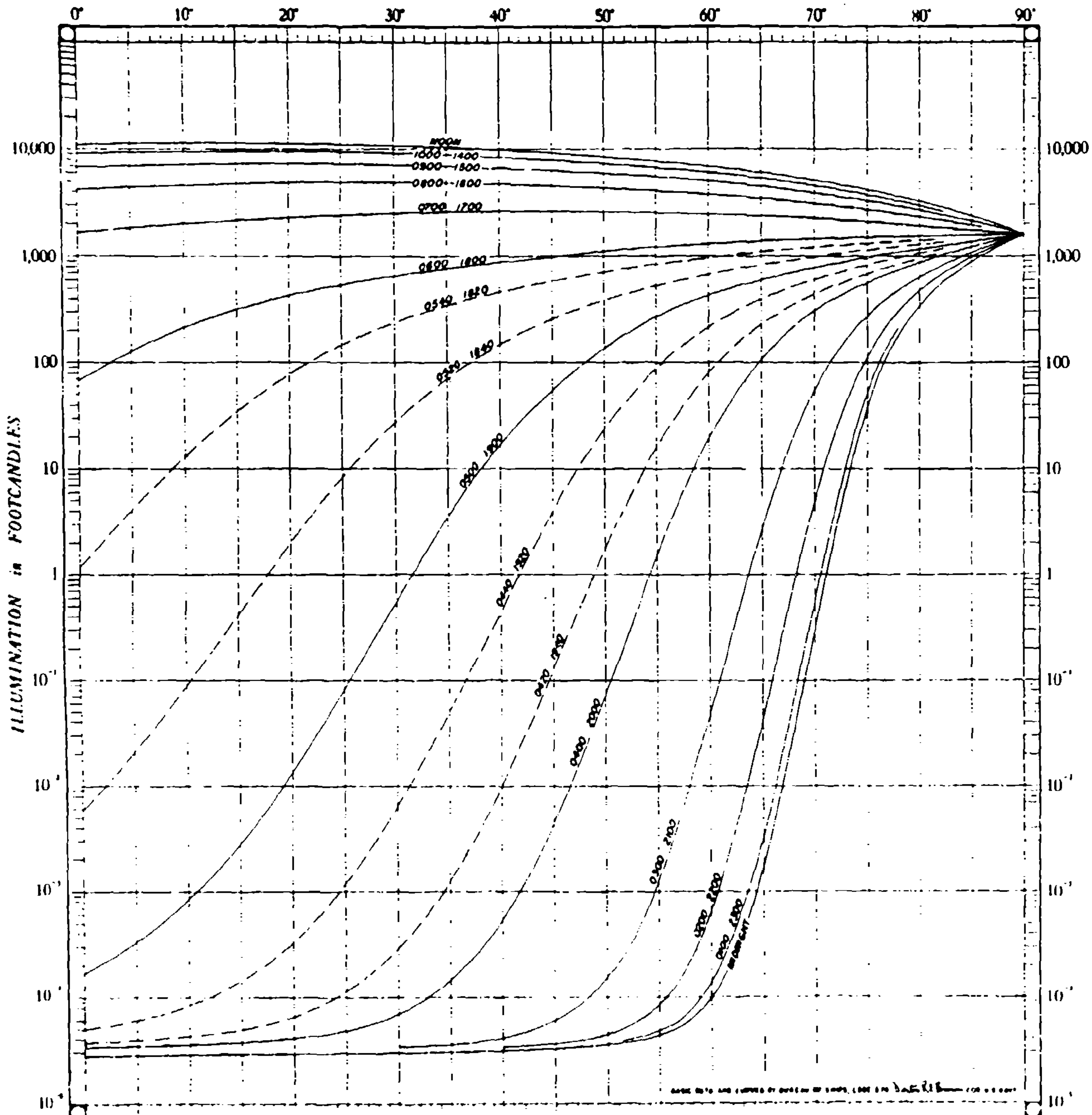
DECLINATION
14° Latitude CONTRARY to declination



Each curve is for a given hour of LOCAL APPARENT TIME as shown

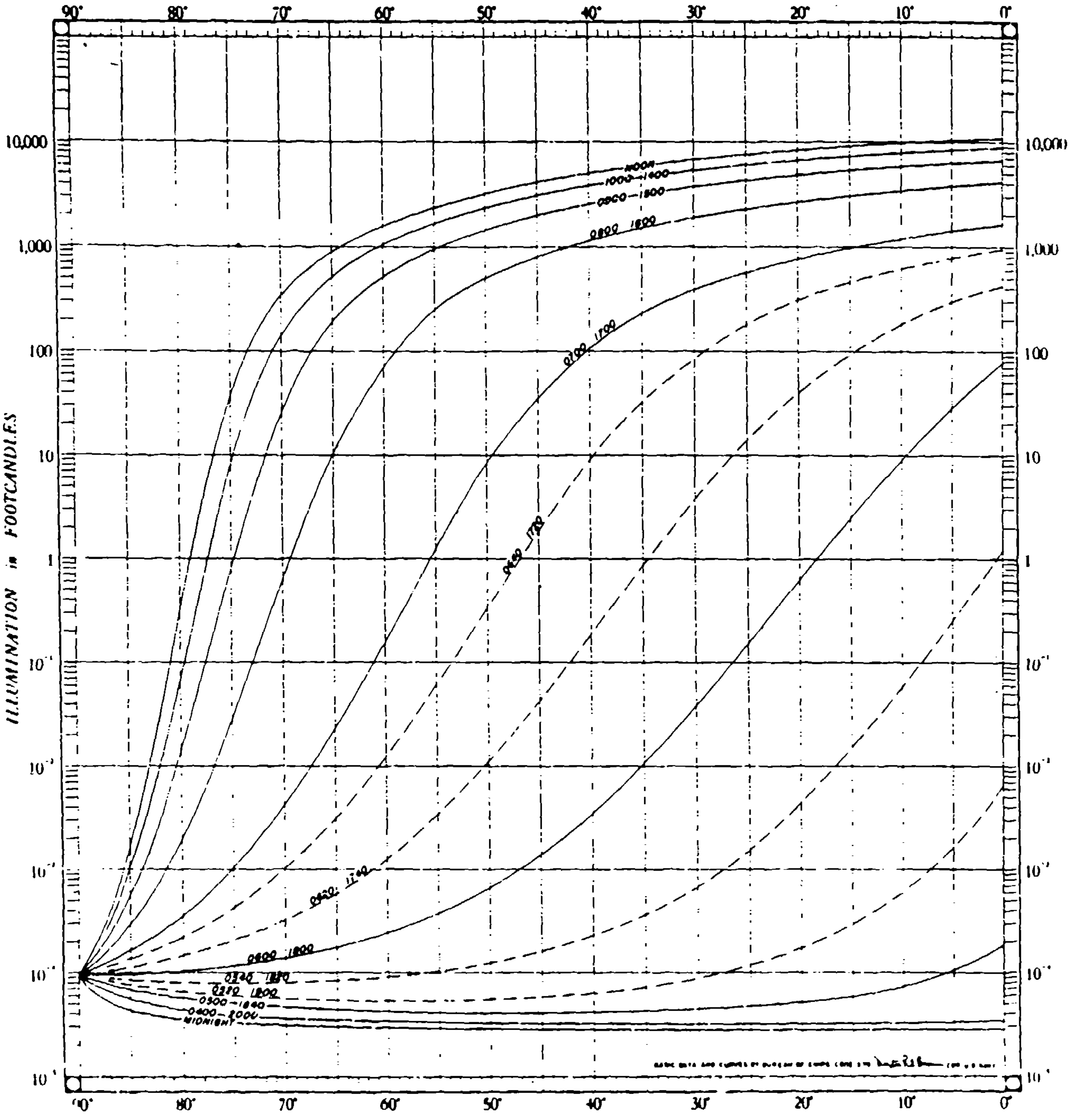
DECLINATION **14°**

Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION
16° Latitude CONTRARY to declination

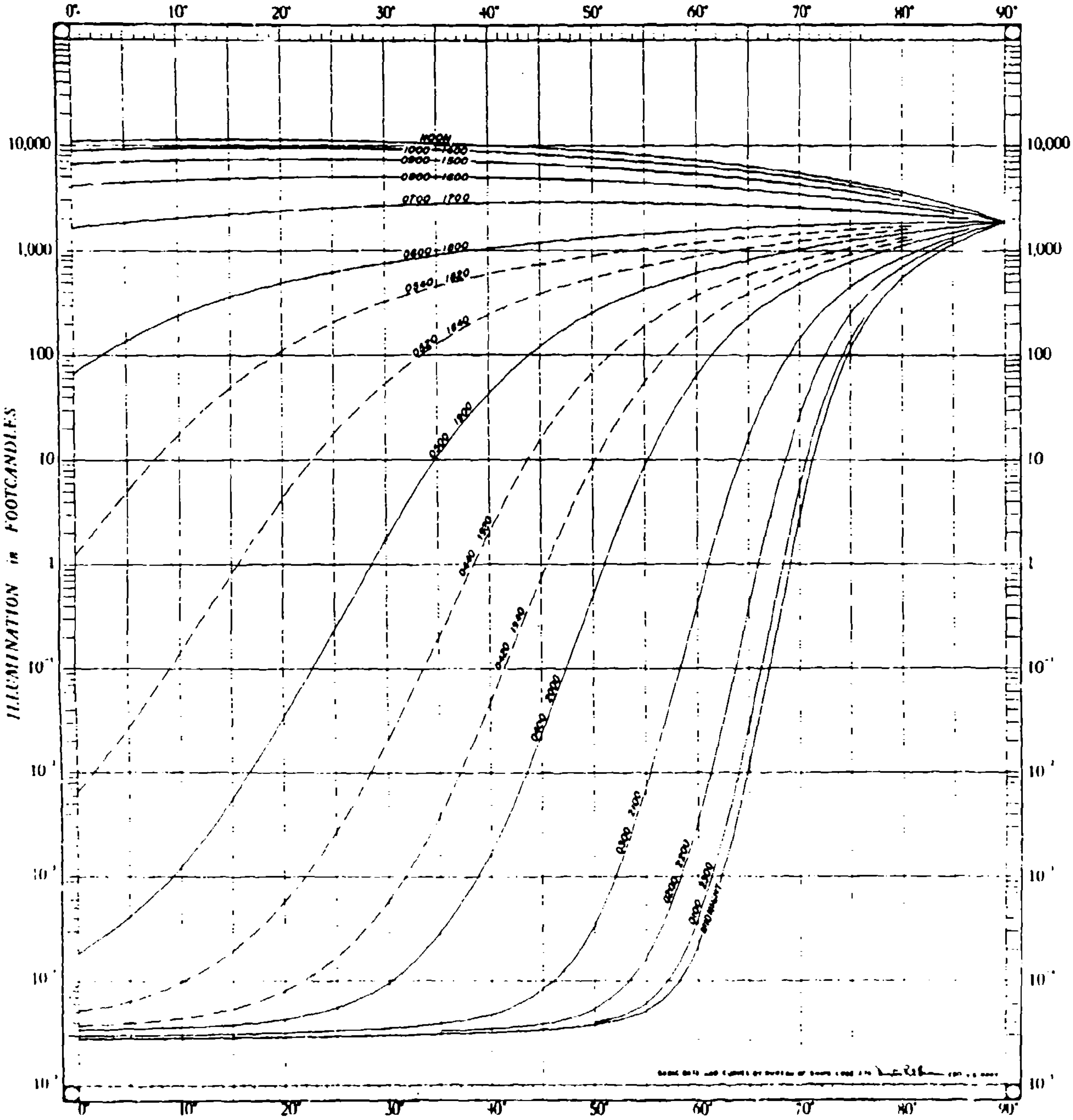


Each curve is for a given hour of LOCAL APPARENT TIME as shown

PLATE H

DECLINATION
16°

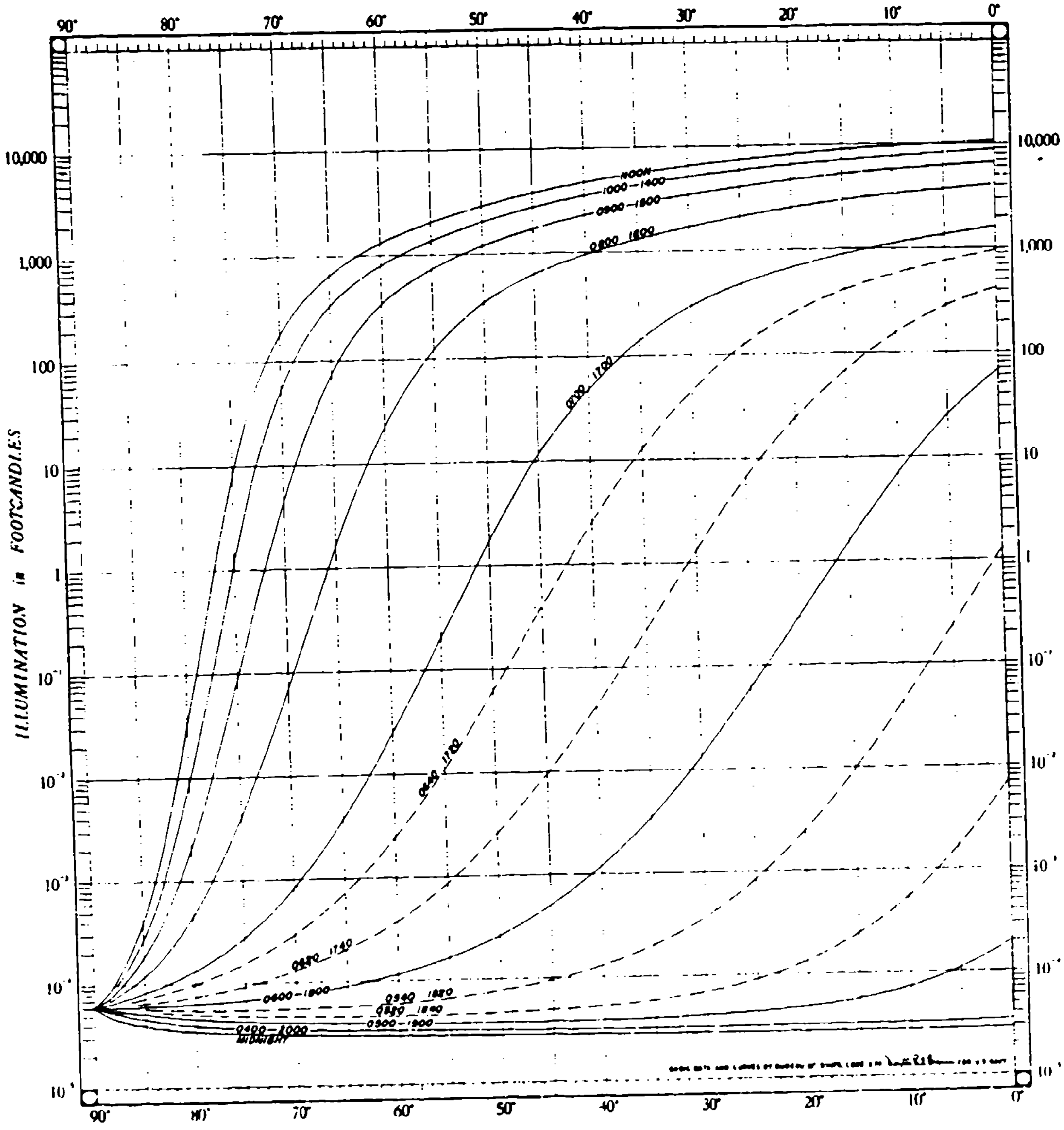
Latitude SAME as declination



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

PLATE 35

DECLINATION
18° Latitude CONTRARY to declination

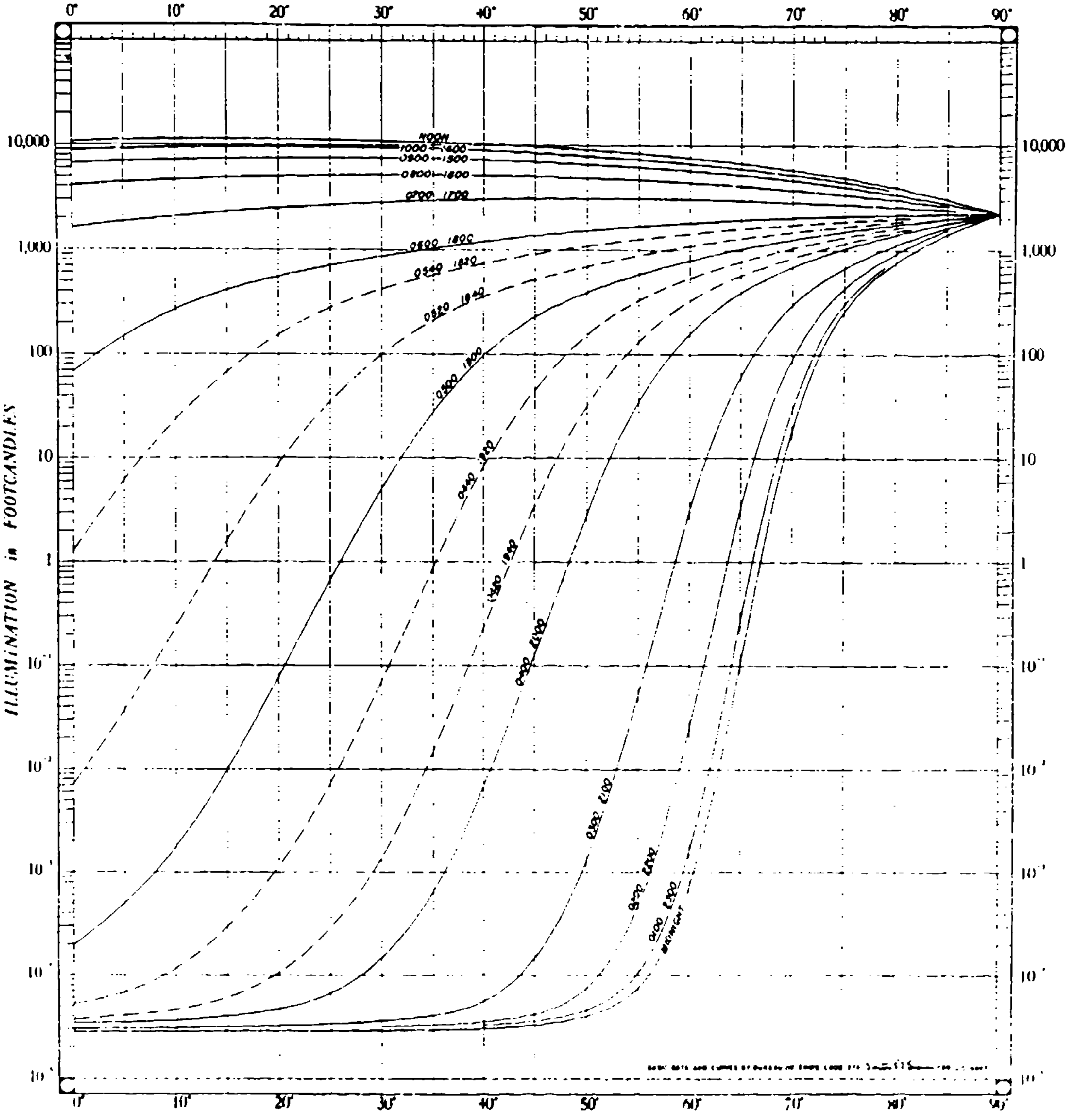


Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

18°

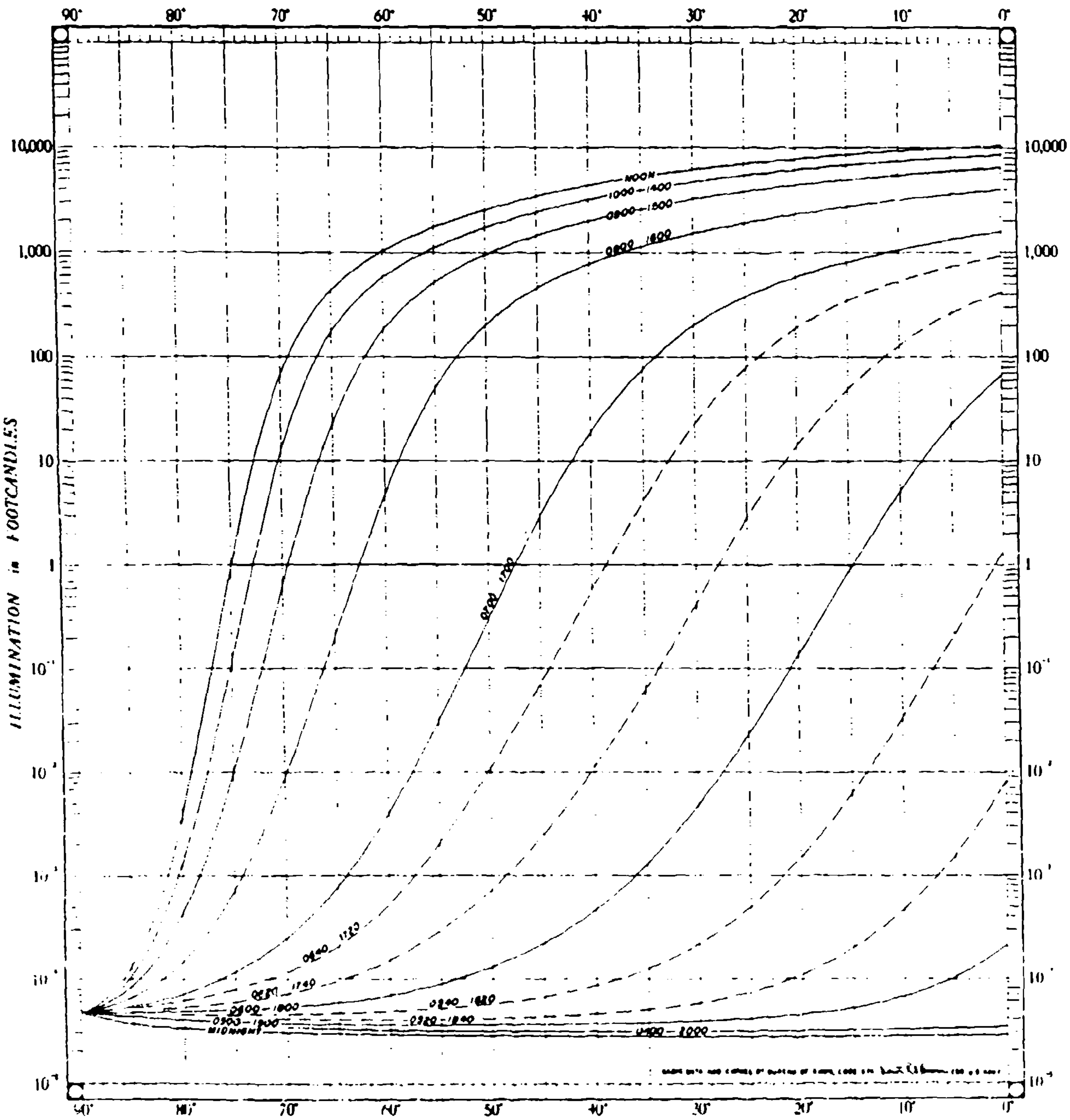
Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

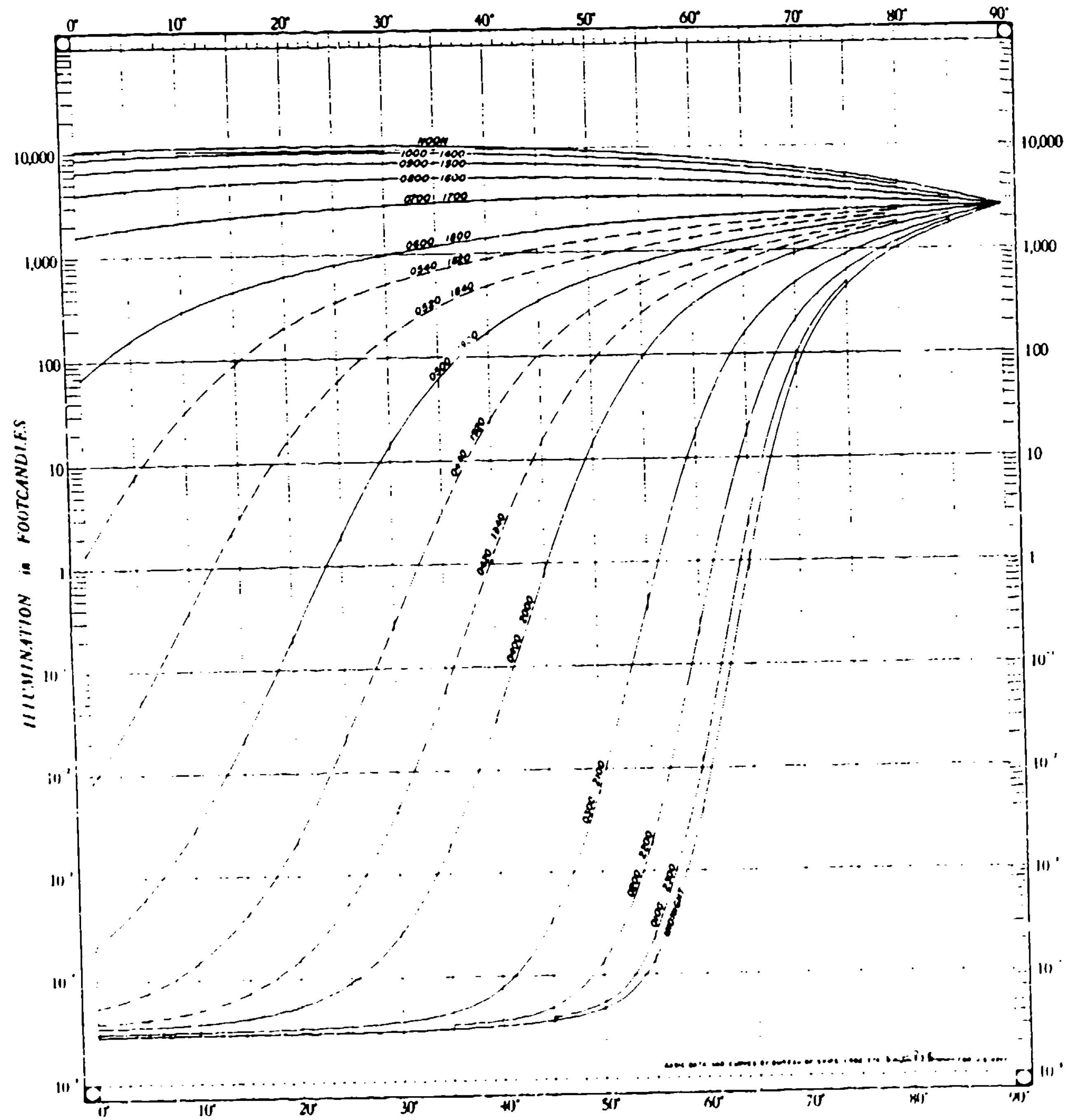
20° Latitude CONTRARY to declination



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

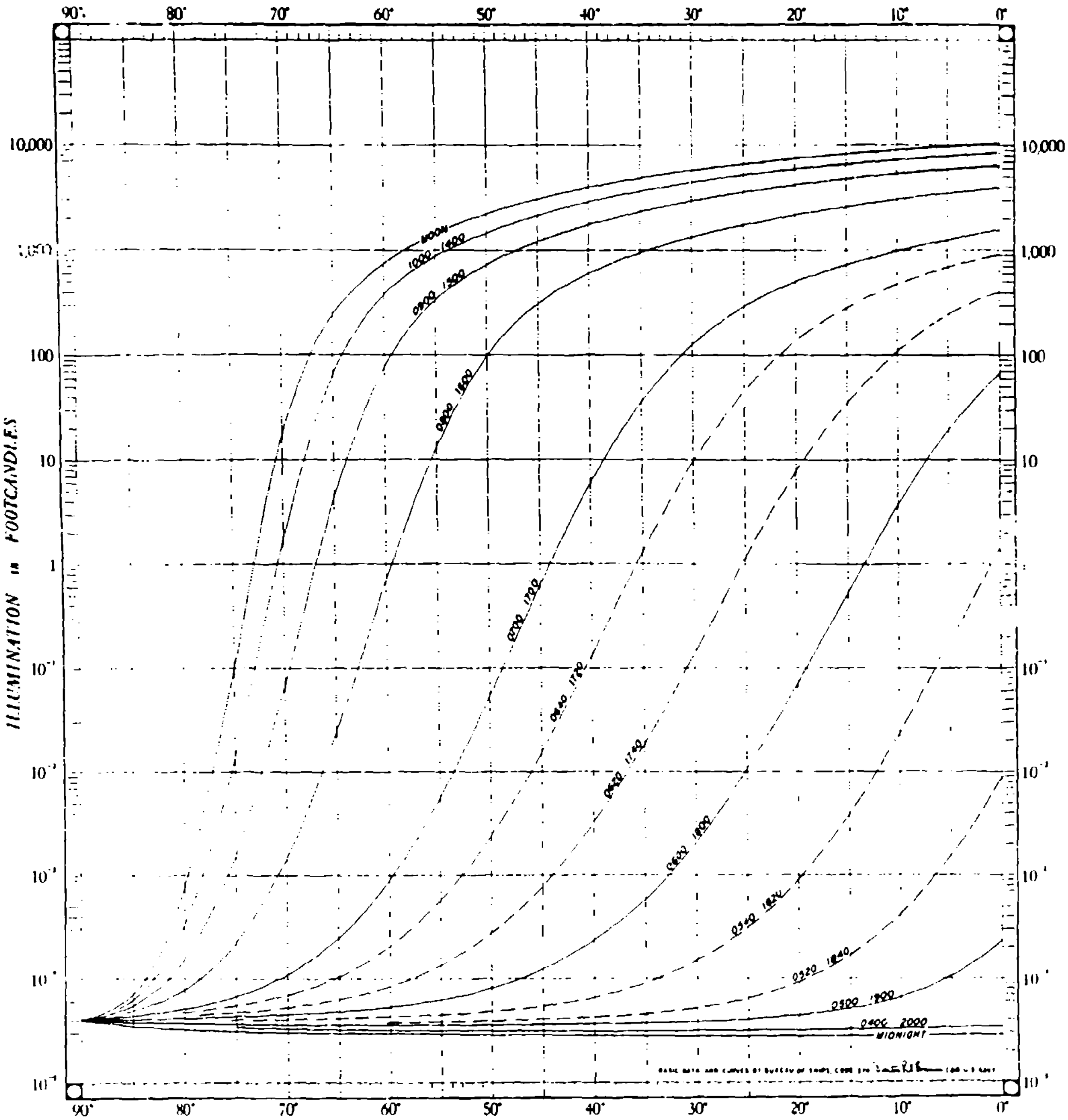
DECLINATION
20°

Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

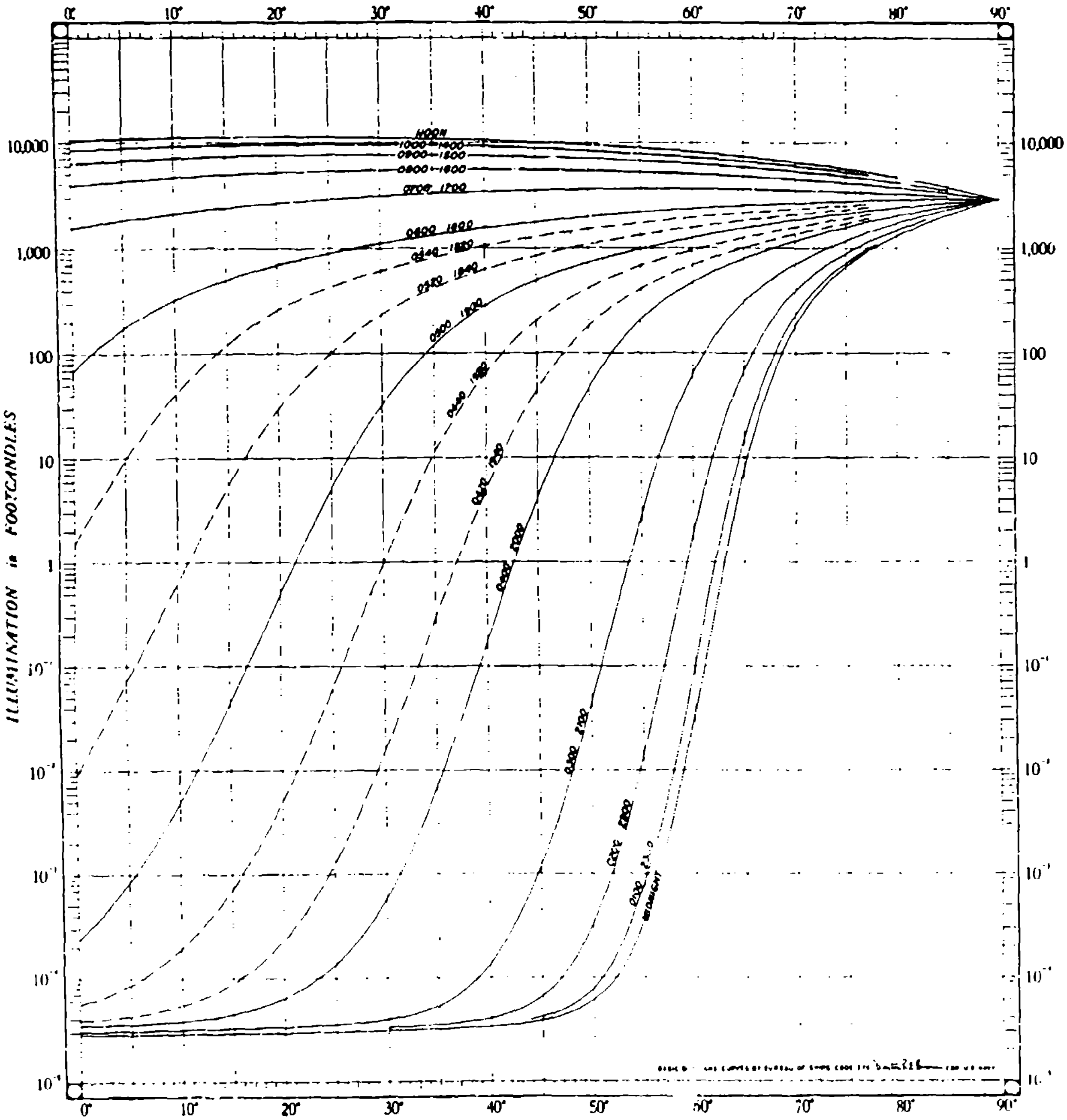
DECLINATION
22° *Latitude* CONTRARY *to declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION 22°

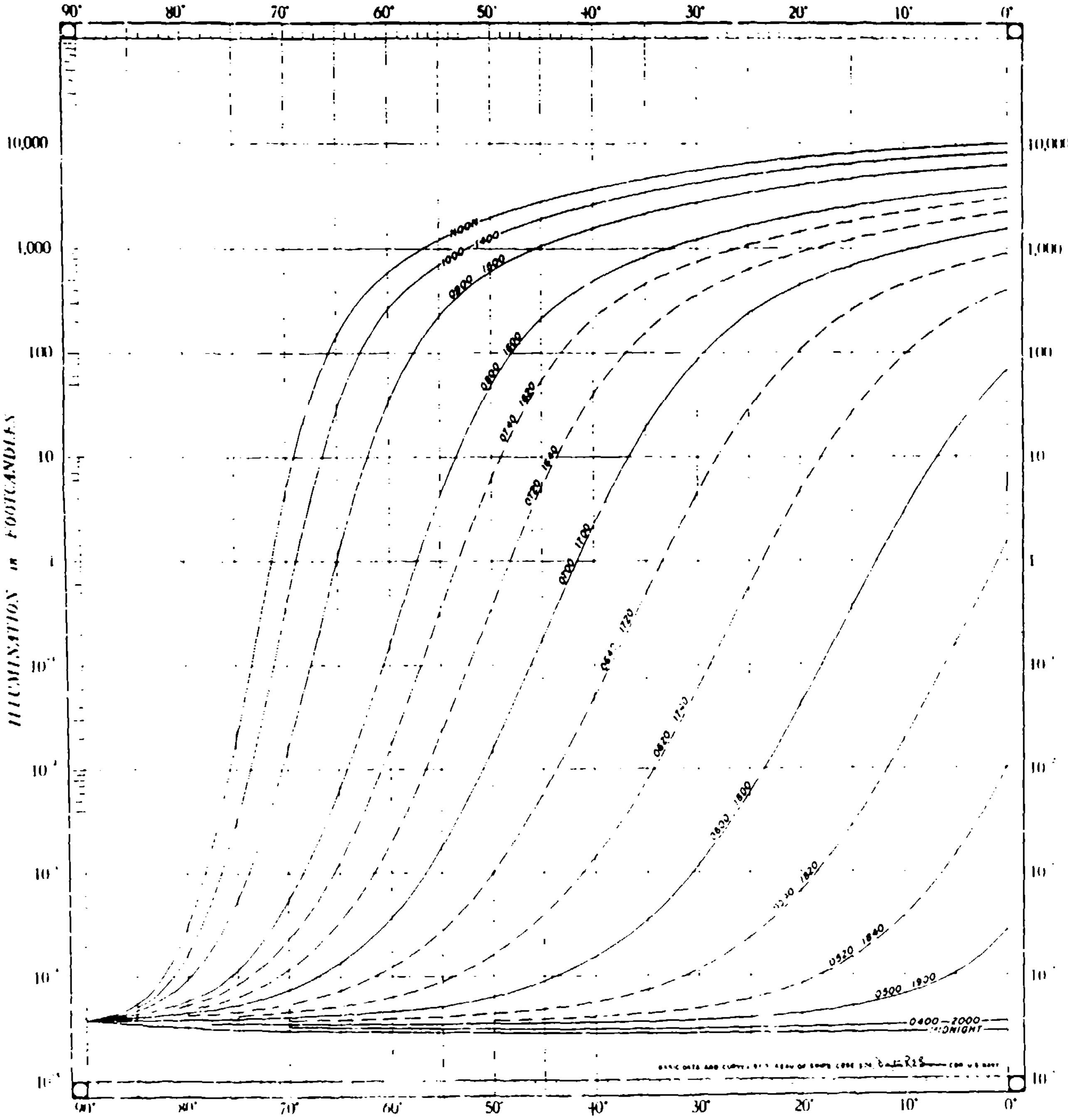
Latitude SAME as declination



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

DECLINATION

23.5° *Latitude* CONTRARY *to declination*

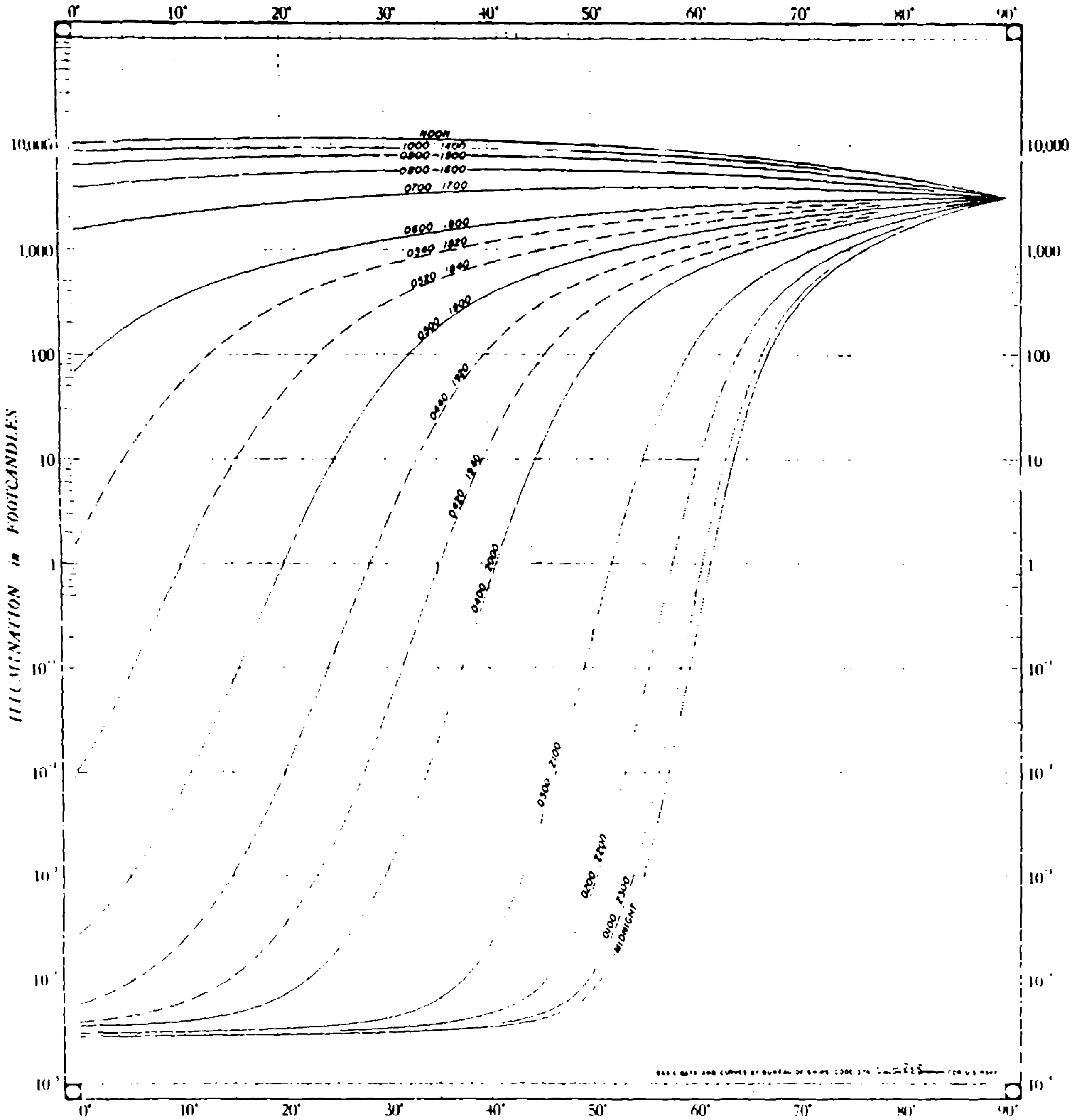


Each curve is for a given hour of LOCAL APPARENT TIME as shown.

PLATE 42

DECLINATION 23.5°

Latitude SAME *as declination*



Each curve is for a given hour of LOCAL APPARENT TIME as shown.

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)
Institute for Defense Analyses

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
Levels of Nocturnal Illumination

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Research Paper, January 1966

5. AUTHOR(S) (Last name, first name, initial)
Biberman, Lucien M., Dunkelman, Lawrence, Fickett, Marion L., Finke, Reinald G.

6. REPORT DATE
January 1966

7a. TOTAL NO. OF PAGES
193

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.
SD-50

b. PROJECT NO.
Task T-36

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

Summary tables show, for four lunar months (mid-summer, mid-fall, mid-winter, and mid-spring), the number of hours in which the illumination exceeds levels in 8 decades from 1.5×10^{-6} lumens per square foot to $1.5 \times 10^{+1}$ lumens per square foot; the full tables list the hours, day by day, in which the illumination exceeds the same 8 levels. Note that the sum of the hours not exceeding and the hours exceeding a given level equals a constant which is the total number of hours in a lunar month.

So that these tables may be more easily understood, they also have been plotted at levels of 1.5×10^{-6}, 1.5×10^{-3}, 1.5×10^{-1}, and $1.5 \times 10^{+1}$. These curves show the number of hours per day as a function of date, the time that terrestrial illumination equals or exceeds these values. There are separate sets of tables for latitudes of 0°, 30°, and 60° latitude.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification